Exploring Urban Rural Interdependence and the Impact of Climate Change in Tanzania and Malawi

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Cover photo: clockwise from top left hand corner: Mapping out the flows connecting urban and rural areas; Situation and scenario analysis women's focus group Dyeratu, Malawi; beans for sale; farmer learning group Southern Highlands Zone Tanzania; project team members; small spring onion plots to ensure more even irrigation, Central Zone Tanzania; tower/vertical gardening Chikwawa, Malawi; Tabianchi groups' sunflower trial, Mtumba village, Tanzania; irrigating Amaranthus, Ihumwa village.

Contents

Acronyms and Abbreviations

AIS	Agricultural Innovation System
ARI	Agricultural Research Institute
BP	Boundary Partner
CAVWOC	Centre for Alternatives for Victimised Women and Children
CC	Climate Change
CCAA	Climate Change Adaptation in Africa
CC&CV	Climate change and climate variability
CKSL	Communication, Knowledge, Sharing and Learning
CURE	Coordination Unit for the Rehabilitation of the Environment
CZ	Central Zone, Tanzania
DALDO	District Agricultural and Livestock Development Officer
FYM	Farm Yard Manure
IDRC	International Development Research Centre
INADES	Institut Africain pour le Development Economique et Social
IRA	Institute of Resource Assessment, University of Dar Es Salaam, Tanzania
m	Month
M	Men
M&E	Monitoring and Evaluation
Met.	Meteorological
MVIWATA	Umbrella Farmer Network in Tanzania
NAPA	National Adaptation Programme of Action
NAREC	Natural Resources & Environment Centre, University of Malawi
NCG	National Consultation Group
NGO	Non Governmental Organisation
NRI	Natural Resources Institute, UK
OM	Outcome Mapping
PAR	Participatory Action Research
R-U	Rural -Urban
SACCOS	Savings and Credit Cooperative Society
SMS	Subject Matter Specialist
SSA	Situation and Scenario Analysis
TMA	Tanzania Meteorology Agency
UDSM	University of Dar es Salaam, Tanzania
VIMI SACCOS	Vikonje, Mtumba, Ihumwa Savings and Credit Cooperative Organisation
W	Women
WAEO	Ward Agricultural Extension Officer

Synthesis

Exploring Urban - Rural Interdependence and the Impact of Climate Change in Tanzania and Malawi

Background

Africa is rapidly urbanizing, by 2030 there are projected to be over 759 million African urban dwellers. This poses major challenges for the further provision of infrastructure and services. Alongside this, Africa is particularly vulnerable to climate change and climate variability (CC&CV).

As urbanisation and inequality increase, more sophisticated analyses of the linkages and interdependencies between rural and urban areas are emerging. Flows of products, people, knowledge and information, natural resources and money provide strong and dynamic linkages.

Objectives of this project

This action research project explored the relationships and dynamics between rural localities and their linked urban centres, focusing on the agriculture and food innovation systems.

It specifically aimed to:

- Develop a collective understanding of the vulnerabilities, roles, climate-related risks and strategies among interdependent rural and urban communities, local government and other key stakeholders.
- Collectively develop and test viable options and strategies for key interdependent rural- urban stakeholders in the agriculture and food innovation systems to adapt to CC&CV; and
- Learn and share lessons for scaling up successful strategies for strengthening adaptive capacity within these interdependent agriculture and food innovation systems.

Methodological approach

An action research multi-stakeholder experiential learning approach was used which built on agricultural innovation systems thinking and sustainable livelihoods theory.

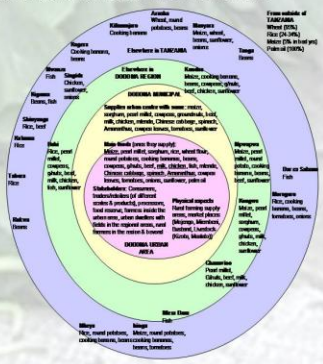
Situation and Scenario Analysis

Reconnaissance surveys found that rural to urban flows were mainly: food staple and cash crops, labour migration for unskilled jobs (seasonal and permanent, mainly men and particularly youth), forest products (e.g. charcoal, building poles, timber), building sediments, livestock and income. Urban to rural flows were mainly: clothes, household items (e.g. bed sheets, cooking utensils), building materials and tools, agricultural inputs (e.g. fertilizers, pesticides), remittances, income and foods (e.g. rice, beans, fish, groundnuts, bananas, cowpeas, cooking oil, sugar, salt, and soap). Rural to rural flows were mainly food crops and casual labour. Rural-urban linkages were mainly to nearby small urban centres, and a few to capital cities.

Urban food and agricultural systems; drivers of change; characteristics of R-U linkages; perceptions of CC&CV; impact of CC&CV on R-U linkages; adaptation strategies; resilience of systems; opportunities from CC&CV; barriers to change; future scenarios; and responses needed were explored by trans-disciplinary teams in the situation analysis in urban Tanzania (Dodoma and Iringa regions) and Malawi (Blantyre city and urban areas of Chikwawa, Mulanje and Thyolo districts).

In Dodoma perceived CC included decreasing rainfall, with later onset and earlier finish dates, increasing temperatures and strong winds. In Iringa it had become warmer, with less predictable rainfall and increased malaria. These changes had resulted in reduced yields and food availability, increased casual labouring, migration, and vulnerability of women and children.

Food footprint maps were created showing the source of key staples, proteins, fruits, vegetables and fats. In Tanzania, Nov-Mar is the hungry period (food prices are high, school fees and farm inputs need purchasing) Food rends included increasing milling, frying, diversity and purchasing. A knowledge gap regards urban food insecurity was identified.



In Malawi many urban dwellers farm crops in rural areas. CC&CV particularly droughts and floods result in urban food insecurity due to higher food prices and increased rural to urban migration exerting pressure on urban relatives' food budgets and choices. R-U linkages are dominated by the sale of rural grown food crops in urban areas, with the cash received typically going to purchase food products from other locations (including across borders) such as maize, beans and meat plus building, clothing and agricultural products.

Adaptation Action Learning Activities and Findings

The above surveys led to the development of three action research themes.

- Agricultural intensification with a focus on resilient horticultural production and processing for urban, peri-urban and rural dwellers
- Improving access to finance for climate resilience through awareness on CC&CV for financial institutions and vulnerable groups
- Multi-stakeholder exploration of urban livelihood strategies to strengthen adaptation to CC&CV

Combining several aspects of these themes, the project has since 2011 worked with peri-urban vegetable growers (focus on women and youth) and other key players (credit institutions, stockists, extension) within the agriculture innovation system to experiment with different agronomic practices (e.g. pre-planting manure incorporation, different varieties , improved seed bed preparation, pesticide application methods etc) on tomatoes, onions, Chinese cabbage, *Amaranthus*.

Through collective experimentation and raised awareness regards CC&CV these growers and their supporting stakeholders have found ways of reducing the land area and irrigation needed to produce their vegetables, and as a result have also improved their incomes enabling them to invest in their family's education and food, housing, and agricultural activities increasing the resilience of their vegetable production, their livelihoods, and the urban food systems in the face of CC&CV. These farmers are sharing their learning with others and are keen to help in scaling out the adaptation activities.

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Natural Resources and Environment Centre · Natural Resources Institute · INADES FORMATION · CURE · Adaptation

For more detailed information on this work visit the project website http://www.ccaa-urban.or.tz

Research problem

Urban populations in Tanzania are projected to increase from less than 3 million (<15% of the total population) in 1980 to over 25 million (~40%) in 2030 and in Malawi from just over 500,000 (~10%) to over 7 million (>30%). In the foreseeable future, the intermediate cities (with less than 500,000 inhabitants) will account for two-thirds of all African urban growth (UNHABITAT, 2008). This rapid urbanization of Africa poses many challenges for national and local governments regarding the provision of infrastructure and services which are already notably lacking in many areas. Alongside this rapid urbanization climate change is posing a serious global threat, to which Africa - faced with multiple stresses and low adaptive capacity, is particularly vulnerable.

The linkages and interdependencies between rural and urban areas provided by the flows of people, goods, services, information and money is increasingly being recognised as important to both social and ecological concerns. Whilst these urban-rural linkages have been partially explored in Tanzania and Malawi (e.g. Maliro & Mataya, 1996; Bah *et al*., 2003; Bahilgwa *et al*., 2005), the impact of a changing climate on them has not been analysed. These interdependencies have deepened since the 1980s and as a consequence trends and stresses at global, national and local levels affecting livelihoods, food security and access to energy in urban areas have intensified the linkages between and heightened the implications for rural areas and *vice versa*.

There is little evidence that such studies are accessible to or influencing decision makers - particularly local governments. Moving away from the earlier localism of some participatory approaches, there has also been increasing appreciation of the importance of linking participatory processes to wider scale development planning and of the need to understand socio-economic dynamics across scales (e.g. as households change shape in the context of increasing migration, as technological developments occur such as mobile phone technology and services, economic globalisation etc). Climate change is increasing the uncertainties around future trajectories for specific places, and exploring what these trajectories might look like on a longer-timescale is thus a critical aspect of adapting to climate change[1]. Our action research project is thus exploring the linkages between rural localities and centralized mid-scale urban centres in Tanzania and Malawi building on our existing CCAA funded 'Rural' project[2]. However, our focus is the linked urban and rural areas in relation to agriculture and food systems aiming to explore resilience and strengthen the capacity of actors in these innovation systems to respond to climate change and climate variability.

Research Findings

This CCAA funded project has gone through several different stages ranging from fact finding mission and consultative processes during the reconnaissance survey and situation and scenario analysis. The synthesis of findings and further consultations with relevant stakeholders contributed to identification of action research themes; which formed the basis of implementation of action research in the selected sites.

[1] CC projections suggest higher temperatures and greater rainfall variability in the shorter and longer term for project sites. In Malawi there is a declining rainfall trend, with substantial dry season rainfall decreases particularly from Sept-Nov (McSweeney *et al*., 2008; Ngongondo *et al*., 2012). Heavy rainfall events during the rainy season are likely to increase the occurrence of flash floods. Other extreme weather events such as droughts are also expected. In Tanzania the increasing mean annual rainfall trend is expected to continue, with more complex seasonal patterns of change. Details in Appendix 1.

[2] The project team worked in more and less favoured rural areas of Tanzania and Malawi from 2007 to 2011, learning about the key agricultural innovation systems actors' perceptions of, adaptation to, adaptive capacity and future strategies regarding CC &CV. CC is perceived to be happening by local communities and other stakeholders, and through the project they were involved in multi-stakeholder action learning processes to build adaptive capacity for climate change. The impacts of and adaptations to climate changes are also impacting on urban communities and the natural resource base upon which both urban and rural communities depend.

Urban-rural food and agricultural systems and their interdependency

The Situation and Scenario Analysis (SSA) confirmed that urban areas are vulnerable to climate change and climate variability through rural urban linkages such as agricultural and food flows. Stakeholders estimated that over 70 percent of the maize (the main staple) used by urban dwellers originated from the surrounding rural areas. Low crop yields resulting from climate change and climate variability effects directly affect both supply and market prices in urban areas. This in turn affects urban household food security. Although government efforts in both Malawi and Tanzania currently focus mainly on vulnerability interventions in rural areas, it is also important to focus and plan for interventions in urban areas.

Low income urban households are especially vulnerable to climate change and food insecurity because of their low purchasing power and dependency on rural production. In contrast, high income groups are able to buy food in bulk while prices are low and can also travel long distances to source food if necessary. In some cases the high income groups are able to produce their own food in fields they own in the urban surrounding areas. No household food security assessment is done in the focal urban areas in either country. Many key stakeholders surmise that as food is always available in urban markets, urban households must therefore be food secure. However, this does not take into account the differing purchasing power of each income group.

Peri urban areas produce the fresh vegetables (Chinese cabbage, Amaranthus, cabbage, tomatoes, onions, sweet peppers etc.) consumed by urban dwellers. Fresh vegetables form an important and affordable component of urban diets, and provide an important income source in peri-urban low income households which are also highly vulnerable to climate change. However, vegetable supply is seasonal and affected by climate change and variability.

Neither Tanzania nor Malawi has a clear National policy for urban agriculture. The policy and institutional setup at the national level mainly favours rural agricultural activities. Municipal and town councils have set by-laws that regulate agricultural activities in urban areas. These by-laws stipulate areas where agriculture (farming and livestock keeping) is permitted and areas where it is prohibited. Local by-laws effectively make it illegal to farm in most of the built-up areas, so the practice is restricted mainly to peri-urban locations. Our research findings, suggest that the importance of peri urban agriculture in terms of income of producers and nutrition of consumers is underestimated and deserves further support, as well as regulation, at both national and local level.

Vegetable gardening brings in more and faster cash compared to cereal and other field crop production. Hence when rain failure reduces the yield of rainfed crops, vegetable gardening in peri urban areas enables those households to remain food secure.

The study also revealed that most local government officials in urban areas had a significant knowledge gap as regards understanding urban livelihoods. This is a significant issue given the rapid rate of urbanization and impacts of CC&CV. These local authorities view the food security of urban areas as being heavily dependent on production in peri- urban and rural areas and therefore focus their efforts on that crop production. Although crop production has a key role in food security, this overlooks the severity of the differential access to purchased food amongst different wealth groups of urban dwellers. In addition, poverty is seen by these local government officials as a very rural phenomenon, with urban dwellers having many more opportunities for coping strategies.

The study indicated that women, children, youths, the elderly and the poor are among the most vulnerable groups to the impacts of CC&V. Another vulnerable group mentioned included small-scale farmers and livestock keepers within the urban vicinity.

Despite the existence of national policy of working with farmers in groups to facilitate learning and technology transfer, no farmer groups existed in the peri-urban project sites in the focal sites in Tanzania and only a few in Malawi. However, when the project facilitated the formation of horticultural learning groups, the farmer members engaged fully in testing different agricultural innovations implying that if extension implemented the group learning policy in these peri-urban

areas and facilitated discovery-based practical learning opportunities, farmers could significantly improve their horticultural yields. Further research is needed to verify why the service provision to farmer groups' policy is not being implemented in these peri-urban areas.

Collective learning process

Whilst the farmer learning groups were able to explain the differences in outcomes between their traditional horticultural practices and the introduced improved practices (Table 1), their capacity in understanding how to experiment still requires further strengthening.

Findings revealed that farmers now appreciate the importance of working and experimenting in a group in a participatory manner and of sharing the knowledge gained, for example use of appropriate pest and disease control measures. These learning groups led to the rapid uptake of successful technologies on the members' own fields, and on many of the neighbouring and other curious horticultural farmers' fields. The typical proximity of horticultural farmers to each other and the irrigation source is likely to additionally enhance the process of sharing of new knowledge. Some group members are quick to understand and others have experience in some of the activities hence their participation increases the chances of them sharing their knowledge and expertise with others. Furthermore, belonging to a group increases the chances of easier access to market information which reduces the probability of farmers being exploited by middle men.

Table 1. Farmers' assessment of the introduced vegetable production practices which they tested

Pre-project practice	Introduced practice	Benefits	Farmers assessment of introduced practices
Spreading FYM on top of soil after planting	Pre-planting incorporation of FYM into the soil	-Soil structure improvement -Improved soil moisture retention and soil nutrition	-Reduced irrigation frequency from daily to every 3 days -Significant increase in crop yield -More frequent leaf plucking and longer plucking period -Reduced time to first harvest (earliness) -Improved quality of leaves attracting higher prices
No mulching	Mulching	Improved soil moisture retention	-Reduced irrigation frequency from daily to every 3 days -Reduced weeding frequency -Significant increase in crop yield
Raised beds in dry season	Sunken beds	Improved soil moisture retention	-Reduced frequency of watering
Flat beds	Trench for tomato	Improved soil moisture retention	-Reduced frequency of watering
Wide seed beds (2.5-3 3m) with uneven surface	Narrow seed bed width (1.0 to 1.2m) with level surface	Easier movement for crop management	-Easy to manage and less soil compaction -Uniform distribution of water in the bed -Reduced runoff of manure due to even seedbed
Broadcasting	Planting in rows at recommended spacing	Optimum plant population	-Even emergence and therefore uniform competition among plants -Using less seed
Normal seedbed practice	Tower/vertical gardening	Reduce irrigation and land requirement	-Proximity to homestead -Appropriate technology for vulnerable e.g. elderly -Reduced weeding regimes -Low pest and disease pressure -No seasonality in terms of production -Can continue using the same soil more than 3 times -Appropriate for farmers with no access to irrigated land
Pesticide application with perforated bottle or bunch of leaves	Spraying using knapsack sprayer	Right application amount and procedure	-Less frequent application of pesticides and observed to be more effective. -Less chemical burning and less insect damage due to in-appropriate application method.

The study further revealed that collaboration with other stakeholders was appreciated by the boundary partners. For example increased interaction between farmers and stockists helped the input supplier to stock relevant inputs demanded by the learning groups and individual farmers who had adopted the technologies. This reduced shelf life for supplies. Further, farmers were able to access appropriate seeds and pesticides locally and in affordable packages. Additionally, participation of the extension officers enabled them to experiment, monitor and evaluate the technologies together with the farmers. This enabled them to advice the farmers appropriately and hence easy to upscale the activities.

Additionally, the study revealed farmers were empowered in sourcing information and extension services. Farmer groups also integrated gender aspects and vulnerable groups. For example, women and the youth were well represented, comprising over 50% of the participating farmers. Other technologies such as vertical/tower gardening could easily be managed by vulnerable groups after initial set up. Linking farmers to other stakeholders and subsequently empowering farmers to make their own links or contacts is key to strengthening adaptive capacity. This changes farmers from being passive participants to active agents with much greater ability to address their information and other needs.

The ability of the participating farmers and stakeholders to experiment in order to solve problems related to climatic and other changes enables them to adapt to change in an informed way which helps them develop more resilient livelihoods. They already found ways of using less water and land to produce their vegetables which given the trend of increasing urban population and therefore increasing demand for vegetables in the urban centres will help peri-urban farmers keep producing vegetables as water resources and land decrease.

Awareness and training on climate change and entrepreneurship

The study established that supplementary trainings on simple technologies such as vertical/tower gardening, climate variability impacts on horticultural production, entrepreneurship, on-farm horticultural production and group dynamics helped to improve the quality and quantity of vegetables produced in peri urban areas and their more constant supply to the market throughout the year. Some farmers also grew vegetables which were previously thought not to be suitable for the area e.g. cabbage and onions in Chikhwawa, Malawi. The activities hence contribute to increased household incomes for peri-urban producers and availability of vegetables to urban consumers.

Horticultural production can be incorporated into a situation where land and water are scarce using appropriate technologies such as tower gardens. Horticultural systems can be adapted to improve the capacity of vulnerable people and strengthen the resilience of the urban food systems.

There is a readily available market for vegetables at the local level. The projected increasing rate of urbanisation will ensure that vegetable demand continues to rise. However supply is seasonal due to the limited supply of water for irrigation in the dry season. Population increase and changes in food choices together with climate change are leading to growing of crops such as high value – exotic vegetables (including cabbage, Chinese cabbage, spring onions, onions and coriander) that are less suitable to the biophysical environment. Whilst in the short term some of these crops can be used for adaptation, in the long term there is a need to find high value vegetables that are more resilient to climate. For example, those that use water efficiently. It is likely that some of the indigenous vegetables can be assumed to be more water use efficient, although trials have not looked at this. The supposition is based on the fact that many of them typically grow as wild plants as opposed to under farmer management.

Assessment of the learning approach

This was the first time studies exploring R-U linkages and CC were done in either Tanzania or Malawi. Information was gained through the use of a participatory multi-stakeholder learning process. This has helped to raise awareness amongst local government and other stakeholders regarding urban-rural linkages in general and food and agricultural systems in particular. In Malawi, urban agriculture is now to be incorporated into national (agricultural and urban planning policy for peri-urban areas) and local government (district agricultural plans) policy.

The study further established that the PAR or participatory learning (learning-by doing) approach both strengthened farmers' ability to analyze and identify ways of improving their situation and to achieve rapid uptake of technologies (compared to demo plots for example).This was evidenced by the number of farmers who had already transferred most of the successful practices they had learnt on the learning plot to their own individual plots, and had supported some of their non-participating neighbours in using the practices as well.

The study noted the importance of process documentation. This helped the farmers to keep records and understand the production cost; and differentiate the output, seasons and proper crop management. Process documentation was essential for monitoring and evaluation and to enhance knowledge sharing in adapting to CC&CV.

The project's initial situation analysis activities identified a wide range of action research opportunities, but the project's resources meant we were only able to respond to a small number of these opportunities. The importance of developing links between urban and rural local governments was confirmed, but not achieved in this project. The gap between extension policy and implementation was highlighted by the activities. For example, groups and participatory learning are part of national policy in both countries but implementation is limited. These and other opportunities identified could form the basis of a further action research project or even programme.

Fulfilment of objectives

General objective

To strengthen the capacity of individuals, organisations and systems within the agriculture and food innovation systems connecting rural and urban communities in Tanzania and Malawi to adapt to the challenges and opportunities arising from CC&CV.

Through bringing key stakeholders within the urban-rural linked food and agricultural systems together to work on sharing and developing a deeper understanding of urban-rural food and agricultural interdependency and then supporting collective field learning activities, the individual horticultural producers who supply the urban centres with their fresh vegetables have been able to improve their productivity while simultaneously reducing the land area and water requirements (see Table 1 for overview, or Appendix 2 for summary of technical details and findings). The improved income from this has been invested into a range of livelihood activities including their household horticulture, food quality, family's education, shelter, and social support networks.

The key organisations involved (zonal researchers, local government, agricultural extension, savings and credit, stockists, meteorological services) have increased their understanding of: the science of CC&CV, CC adaptation strategies; urban livelihoods and the interdependency of urban-rural food and agricultural systems. However, there is mixed evidence regards whether this increased understanding has then been applied, and therefore whether the innovation systems capacity has in practice been strengthened to adapt to the challenges and opportunities arising from CC&CV. The farmers' findings from the field learning plots together with the increased understanding of CC&CV and urban-rural interdependency throughout the individuals and organisations in the innovation system mean the learning could theoretically now be scaled out and up to drive CC adaptation throughout the system in the next couple of years.

Specific objectives

Objective 1: To develop a collective understanding of the vulnerabilities, roles, climate-related risks and strategies among interdependent rural and urban communities, local government and other key stakeholders.

Outcome 1: Focal urban and rural communities and other key stakeholders better understand the interdependencies, relative resilience and their respective vulnerabilities of their agriculture and food systems to CC & CV.

Outcome 1 indicator: Key stakeholders from focal urban and rural sites able to clearly articulate understanding of the interdependency of their agriculture and food strategies by month 18

The reconnaissance surveys and situation and scenario analyses (SSA) provided different key stakeholders with the opportunity of mapping out the flows and linkages between the urban and rural food and agricultural systems and contemplating the impact of CC&CV on these interdependencies. These stakeholders identified and discussed:

- the main urban food types;
- the trend changes in urban food type and form over time, and the drivers of these changes;
- the seasonal and permanent trade routes of different foods consumed in the urban centres;
- the rural-urban and urban-rural flows of crops, labour, building materials, information and income;
- food security strategies of urban dwellers disaggregated by stakeholder type and wealth category;
- urban agricultural activities;
- the interdependency of rural areas with their different urban centres;
- urban stakeholders' perceptions of CC&CV and associated vulnerability.

This information is reported in the: Inception workshop report; Reconnaissance survey report; and Situation and Scenario Analyses for Tanzania and Malawi. It became clear that in the medium and small urban settlements, service providers assumed that all urban dwellers were less vulnerable than rural dwellers. There was a significant knowledge gap concerning urban food security and livelihood strategies/ vulnerability. Urban agricultural service providers tended to be focusing on the remaining rural parts of their urban area as opposed to addressing urban or peri-urban issues. Urban dwellers were aware of rapid urbanisation, and the impact this was having on their access to nearby farming land as these areas were increasingly being converted for residential and urban development.

Objective 2: To collectively develop and test viable options and strategies for key interdependent rural-urban stakeholders in the agriculture and food innovation systems to adapt to CC&CV.

Outcome 2: Information, training and product demands of interdependent urban and rural communities and other key stakeholders for strengthening their agriculture and food security strategies to adapt to CC&CV are identified and shared.

Outcome 2 indicator: Action plans of strategies for strengthening capacity of interdependent urban and rural communities and other key stakeholders in relation to CC adaptation of their agricultural and food systems agreed on by end of month 12.

The SSA asked the wide range of participating stakeholders to identify their information, training, product and institutional arrangement needs to help strengthen their urban-rural dependent food and agricultural systems in adapting to CC&CV.

In Tanzania: *Information* needs included: reliable seasonal climate forecasts; and knowledge on functioning CC adaptation strategies from elsewhere. *Training* needs varied amongst stakeholder types and included: how to apply CC knowledge to what is happening on the ground; agricultural adaptation methods; business training; and improved storage. *Product* needs were fairly specific to the different stakeholders and included: transport to reach clients; access to water, uniforms and facilities by food vendors to address food safety issues; irrigation facilities, inputs and agricultural implements; dam construction to help with livestock watering. *Institutional arrangements* needs

included: better links with meteorological services to supply seasonal forecasts and warnings; and easier access to loans.

In Malawi: *Information* needs included: heightened awareness regards the impacts of CC on urban and rural livelihoods and food and agricultural systems, awareness raising on the importance of food and crop diversification and tree planting and environmental conservation. *Training* needs included entrepreneurship skills and management of capital and loans, food processing and value addition. *Product* needs included: access to loans and irrigation equipment. *Institutional arrangement* needs included: improved food marketing and environmental management laws, increased understanding of CC impacts and adaptation opportunities by extensionists (and other stakeholders).

By the end of Year 1, three priority action research themes were collectively developed from the suggestions and information collected from the diverse range of stakeholders consulted during the SSA and reconnaissance surveys. These three themes were:

- Agricultural intensification with a focus on resilient horticultural production and processing for urban, peri-urban and rural dwellers;
- Improving access to finance for climate resilience through awareness on climate change and climate variability for financial institutions and vulnerable groups; and
- Multi-stakeholder exploration of urban livelihood strategies to strengthen adaptation to climate change and climate variability.

During the development of detailed workplans for these three themes it became clear that the project's resources (particularly financial, as well as time) would only be sufficient to support one action research theme in each country. So the first action research theme '*Agricultural intensification with a focus on resilient horticultural production and processing for urban, peri-urban and rural dwellers*' was selected; with the plan of including a focus on climate resilient microfinance and urban livelihoods capacity building to help capture key aspects of the other two originally proposed themes.

Elements of theme 2 were addressed through including local (usually village/ward based) savings projects in the CC awareness seminars and in so doing building their understanding of the challenges and opportunities arising from climate change, and how their clients might be affected and might adapt their livelihoods in the face of CC. It was hoped that by increasing their understanding of CC, it would help them in assessing the types of local level projects they would support with loans. They were also encouraged to visit the horticultural learning plots during the season to gain first hand experience of how these farmers were improving the sustainability of their horticultural farming.

Elements of theme 3 were addressed through building on the multi-stakeholder process used in the situation and scenario analysis during the first year of the project, which explored the different stakeholders understandings of urban livelihoods, and then shared these different perspectives in order to help develop a more solid understanding of this area. The involvement of the different stakeholders in the learning plots and CC seminars helped deepen their understanding of the role of horticulture in the livelihoods of peri-urban dwellers and in the urban food system, and of urban vulnerability to CC.

Outcome 3: Interdependent urban and rural communities have enhanced capacity to adapt their agricultural and food security strategies through experiential learning and testing of alternative strategies (including improved: access to information; linkages with other stakeholders; understanding of potential impacts of CC&CV and resilience of system in question).

Outcome 3 indicator: X individuals (y% women, z% vulnerable) in the 4 focal urban and rural communities per country are using their improved: access to information, linkages with other stakeholders; understanding of CC and CV and experiential learning to enhance their agricultural and food security strategies according to their own indicators by end of Yr 3.

Following the identification of the action research themes from the SSA findings, the project coordination team worked with local government staff to identify the focal communities to work intensively with the project[3]. A community baseline study was then done with each of these focal horticultural producing communities.

At least four horticultural farmer learning groups in each of Tanzania (3 groups in Central Zone (Year 2&3), and 2 in Southern Highlands Zone (Year 3)) and Malawi (2 groups in Chikwawa district (Year 2&3) and 2 in Mulanje district of Southern Region (Year3)) worked with a mix of stakeholders (particularly agricultural research and extension, with some interaction with savings and credit organisations, meteorological services, NGOs and media). An experiential learning approach was used to learn through actually testing and comparing different horticultural production techniques (e.g. different ways of using manure, compost and fertilisers, use of new varieties, different seed bed preparation techniques, different method of applying pesticides). This practical experimentation was complemented with a series of seminars which covered: CC science, impacts and adaptation strategies; training in record keeping and process documentation; visits to: other horticultural farmer groups, CC adaptation learning groups, agricultural field shows (e.g. NaneNane), and agricultural research stations. Just over half (55%) of the farmer group members were women. Although many of the members considered themselves to be in the poorer category (not extremely poor) at the start of the group learning activities, after 9-18 months participation they explained that their resulting increased horticultural income (*see Appendix 2 for summary of technical details of increased horticultural income*) meant they were now mostly in the middle income category[4]. They explained that this meant they could now afford: more desired food types; to improve and build houses; send their children to school, invest in their agricultural activities and set up small businesses. There were physically disabled, elderly, and female headed household members in the groups.

During the learning visits in 2012, the farmer groups members explained that they had increased their per unit area production of horticultural crops through using the new agronomic practices (e.g. incorporating manure into the soil pre-planting as opposed to sprinkling it over the soil surface after planting; correct dilution and droplet spraying of insecticides and fungicides as opposed to splashing pesticides over their horticultural crops with a perforated bottle cap or leafy twigs dipped in the pesticide water mixture; preparation of much narrower seed and planting beds which can be more easily and evenly watered and learning how to ensure the soil surface was level to prevent uneven

[3] The selection drew on the understanding developed during the reconnaissance study of the types of urban and rural linkages between the focal rural villages of the sister CCAA project in Tanzania and Malawi. Once the different kinds of flows between those rural areas and different sized urban centres were understood, a more detailed situation and scenario analysis of the linked urban areas was done. The rural sister project's focal villages represented 4 villages in semi-arid low potential parts of Tanzania, and 4 in Malawi; and 4 villages in high potential/more favoured parts of Tanzania, and similarly 4 in Malawi. In 2007 that project initiated the learning on how CC was affecting livelihoods in these different locations. In this urban project the focus was on the urban sites which those focal rural villages interlinked with; with a focus on horticultural learning groups in the less favoured/ semi-arid zones eg Central Zone Tanzania and Chikhwawa district, Malawi in Year 2, and the more favoured parts e.g. Njombe, Tanzania and Mulanje, Malawi in Year 3.

[4] Details of the community's perspectives of the assets, food, energy and coping strategies in bad years of three income groups are described for each urban community visited in the SSA reports.

water collection, and use of line and spaced planting which all improved plant establishment and yields) (*see Appendix 2 for summary of technical details*). Farmers reported that they could now use smaller land areas to produce the same amount of produce. The improvement of their soils through incorporation of manure and use of mulching resulted in them being able to reduce the frequency of irrigation required (which is a major labour saving). Record keeping skills enabled them to understand the differences in their crops maturity periods at different times of year and to use this in forecasting what quantities of harvest they would have when, and to plan their marketing strategies accordingly. The farmer groups in semi-arid Central Zone, Tanzania have also tested alternative crops such as sunflower and experimented with varieties and soil preparation practices that perform well under highly variable rainfall conditions to further help diversify and protect their livelihoods in the face of CC&CV.

Improved horticultural yields had translated into improved incomes and significant interest from other non-participating horticultural farmers. The group members had invested their improved incomes in their family's education, improved foods, shelter (roofing materials), agricultural inputs, and support to others. Several of the farmers had already been invited by curious non-participating farmers in their own and neighbouring villages to train them on the successful techniques they had tested.

Outcome 4. Local governments and other key stakeholders have co-developed and started to practice strategies for reducing their vulnerability by addressing the climate related risks of interdependent urban and rural agricultural and food systems.

Outcome 4 indicator: X local government staff and Y other stakeholders can describe the strategies they have co-developed to strengthen capacity and can report on implementation progress and the resulting changes by month 24 and 36.

Local government staff based close to the learning groups (e.g. ward extensionists or ward councillors or village based savings and credit organisations, community development officer) and the project teams local researchers worked with the farmer learning groups in setting up, testing and evaluating agronomic practices. In Tanzania, the linkage and communication between district level extensionists and their ward level staff was variable. In Central Zone, although the district level staff were involved in the early stages (SSA) of the project and in training seminars on CC, they had not visited the nearby learning plots when invited or followed up to find out about the activities their ward level staff were involved in. Such weaknesses have serious implications for formal scaling up and out of agricultural CC adaptation learning. Future projects need to develop an understanding of the actual linkage and communication practices between these district and local levels, and the associated challenges in order to try and sustainably strengthen the functioning of this important aspect of the innovation system.

In Malawi, the project team keenly encouraged and facilitated the ongoing involvement of the other key stakeholders (the stockists, DALDO, crops officer, section and village level agricultural extension, local NGO) in the learning plots. These stakeholders were then able to respond to farmers' emerging demands, such as locally stocking (and therefore selling) the inputs demanded by the farmers. The DALDOs office incorporated additional visiting of the learning plots into their own work programme, while the met office complained they did not have the resources to do this. The media visited during the annual field days and used their learning to develop and broadcast TV and radio programmes on the learning.

In order to have a long-term sustainable learning process the government officers need develop ownership and initiative regards linking with the learning groups and up-scaling the activities. As discussed above, more attention needs to be focused on how to build up such ownership amongst the local stakeholders in order to increase impact and longevity of the investments.

Objective 3: To learn and share lessons (through process documentation) for scaling up successful strategies for strengthening capacity at individual, organisational and system levels within the interdependent agriculture and food innovation systems in linked urban and rural settings to adapt to the challenges and opportunities brought about by CC&CV.

Outcome 5. Meaningful communication, knowledge sharing and learning by project stakeholders.

Outcome 5 indicator: CKSL plan co-developed by stakeholders by month 10. Range of different CKSL outputs exist and reflective learning on them is reported on in 6 monthly reports.

The project developed its communication, knowledge, sharing and learning plan during Year 1.

Collective learning-by-doing field plots formed the central focus of the project's field activities, and these were developed by the farmer/ researcher/ extension/ local government horticultural learning groups and then visited at intervals by other stakeholders such as the savings and credit organisations, meteorological services, media and other NGO and research members of the project team. Neighbouring non-participating farmers have been curious about the learning plots and many have asked for and been given training from the participating farmers on the techniques.

Several stakeholder workshops were held to gather and share information regarding the project's activities (e.g. urban food and agricultural systems mini-meetings, CC science and adaptation stakeholders meeting). Visits were arranged for the learning groups to see and interact with other CC adaptation or horticultural learning groups (e.g. Chibelela village, Central Zone, Tanzania to learn about more adaptive sunflower production; Zakudimba cooperative, Southern Malawi to learn about production, smooth market supply and processing of vegetables; Marieta Foods fruit and vegetable processors in Njombe, Tanzania; other horticultural farmer learning groups in nearby villages). Visits were also arranged to the national agricultural shows (e.g. NaneNane), to Bvumbwe agricultural research station (to see their horticultural activities).

The learning groups received training courses in entrepreneurship skills, record keeping and process documentation, in addition to the CC science and adaptation seminars and the hands on field learning activities.

The process documentation by the farmer learning groups and project team was shared in the various stakeholder workshops and seminars. A series of project flyers/leaflets were developed (and frequently translated to Swahili and Chichewa) to inform stakeholders about the projects activities and progress (e.g. Nov 2009, Nov 2010, June 2011). A village info poster was developed in May 2012, to enable farmers to raise awareness about their activities.

The project developed its website http://www.ccaa-urban.or.tz at the start of the project and shared technical reports and flyers through it. The project's learning was used to inform two policy briefs, a CCAA book chapter, and several conference presentations. The project coordination team took regular video footage of the learning process, and this will be edited into short films for use in scaling out and up activities by the farmers or the other stakeholders involved.

The media stakeholders in Malawi published several newspaper articles about the projects activities and learning, and TV and radio documentaries. Although the media in Tanzania were also facilitated to visit the learning plots and attend the CC training seminars they have not yet used these experiences to produce any media disseminations.

Outcome 6. Understanding of and evidence for behavioural change amongst key stakeholders in the interdependent urban and rural agriculture and food innovation systems.

Outcome 6 indicator: Project team have used situation analysis & stakeholder consultation findings to understand current constraints between stakeholders & have developed OM progress markers for different stakeholders to help identify & monitor (easy, medium and hard) behavioural changes. Progress & outcome journaling culture adopted by project team & stakeholders.

Building on the extensive learning regards outcome mapping during the rural CCAA sister project, the project coordination team developed an outcome map. During the May/June 2012 learning visits following between 9-18 months of learning plot activities, the different boundary partners' progress against their (easy, medium and hard) progress markers was monitored. There were significant achievements regards the easy/expect to see, medium/like to see markers and some progress regards the hard/ love to see markers especially by farmers in learning groups (see Learning Visit reports for details). The project teams OM journaling was updated in each of the 6 monthly reports.

During the first year of the project, two team members attended an IDRC run 'process documentation' training, and the project subsequently adopted a process documentation approach at farmer and project team level. This recorded what had been done, when, why, how and by whom, and detailed the perceived achievements (what went well), challenges (what did not go so well), emerging issues, lessons, resolutions, learning and future plans.

Project design and implementation

The activities supported under the project are shown below (*see left hand column*); their time frame, the research methods and analytical techniques and any problems encountered are discussed.

Table 2. Details of the research methods and analytical techniques followed for each activity

Project Activities, *Milestones & Outputs*	**Details**	**Year**
Objective 1. To develop a collective understanding of the vulnerabilities, roles, climate related risks and strategies among interdependent rural and urban communities, local government and other key stakeholders.		
Act 1.1 - Project inception & annual planning meetings. *Inception by month 3, & report by month 6. Annual planning meetings – month 14 & 26, and reported by month 16 & 28 respectively.*	Inception workshop: 23-27 Sept 2009, in Blantyre, Malawi. Full project team, ownership building of proposal through group work and presentation of reconnaissance findings, group analysis of flows used to inform planning of future project activities. Workshop report produced and circulated. September 2010 annual planning meeting, Bagamoyo: Presentation of situation and scenario analysis findings; development and prioritisation of action research themes; detailed workplan development for each country's Yr 2 activities. June 2011 annual planning meeting, Kibaha: Overview of action research activities; group planning of Year 3 activities. June 2012 final writeshop, Arusha: Reflection on project process and achievements; upgrading of draft final report sections; development of journal articles and policy briefs for Tanzania and Malawi.	1 2 3
Act 1.2 - Project contracts, subcontracts and financial arrangements agreement. *Subcontracts with collaborators m3 and partners by m8*	Detailed subcontracts between IRA and NAREC and IRA and NRI were iteratively developed and signed in Aug/Sept 2009.	1
Act. 1.3 – Situation analysis of focal urban and rural communities' agriculture, food and energy interdependencies and their perceived vulnerability to CC and other drivers of change. *At least 4 studies per country*	Initial planning of the research questions to be answered in the situation analysis was done during the inception workshop. These covered: characteristics of rural-urban linkages; urban food systems; urban agricultural systems; drivers of change; perceptions of CC&CV; impact of CC&CV on rural-urban linkages; adaptation strategies; resilience of systems; opportunities from CC&CV; barriers to change; future scenarios; responses needed.	1 2

completed by month 7, country reports ready by month 10.	During further planning and method development it was decided to combine the community level situation analysis (Act 1.3) and the stakeholder consultation (Act 1.4) in order to provide a more holistic overview of rural –urban interdependence of food and agricultural systems from a multi-stakeholder perspective. The trans-disciplinary and international (Tz, Mw, UK) nature of the project team was particularly important during this process in helping to incorporate and build on the existing knowledge on urban food systems and urban-rural interdependence and situation analysis and stakeholder consultation methodologies and analysis and reporting skills. Tanzanian Situation and Scenario Analysis (SSA) field work 25th Jan - 6th Feb. 2010 involved 11 project team members (from Tz, Mw & UK), focused on Dodoma (Central Zone) and Iringa (Southern Highlands Zone) regions of Tanzania. Malawian SSA field work 11th -20th May 2010, involving 9 team members (from Mw, Tz & UK), and focusing on urban areas of Southern Malawi (Blantyre City; Chikwawa Boma, Dyeratu and Nchalo in Chikwawa district; Mulanje Boma and Chonde in Mulanje district; Luchenza in Thyolo district). A large number of community and other stakeholder interviews were held, including regional & local government; wholesale and smaller traders & processors of various key commodities; national food reserves; food vendors/ small-scale caterers; market management; brokers; international organizations. The process used individual interviews (key informants), focus group discussions (disaggregating men and women urban dwellers from across the different wealth groups) and multi-stakeholder workshops. Typing up of field notes, preliminary analysis and brainstorming on key findings was done for 2 days after the field work. The project team then divided the reporting responsibilities up amongst themselves. A presentation summarising the findings was developed in August 2010 and also used to summarise the study and inform the planning during the Sept 2010 annual planning meeting.	
Act 1.4 – Stakeholder consultation with local government officers and other key stakeholders to learn about their: understanding of the interdependence of these urban and rural agriculture and food innovation systems; understanding and activities regarding CC adaptation and planning; linkages with other stakeholders; and ITP needs to enhance their capacity to adapt to CC&CV. *Id. of key stakeholders by m7, method by m7, undertaken m 7-10, report m12.*	This began through the Situation and Scenario Analysis in Year 1 (see Act 1.3 above) and during NCG meetings (Tz: Sept 2010; Mw: Nov 2010). Interaction with most of these key stakeholders continued as it was a key part of the learning alliance/ innovation systems/ multi-stakeholder learning approach being used by the project (e.g. during community baseline surveys, experiential learning plots, training seminars, village based process documentation, field days in Malawi, and during discussions in conferences).	1 2
Objective 2. To collectively develop and test viable options and strategies for key interdependent rural-urban stakeholders in the agriculture and food innovation systems to adapt to CC&CV		
Activity 2.1 – Participatory analysis of urban and rural communities' information, training and product (ITP) demands. *At least 4 participatory assessments of interdependent urban and rural communities' demands/country by month 10.*	Using the information from the SSA and reconnaissance study, the following three possible action research themes were developed in a participatory way by the stakeholders and project team during the various consultations: • Agricultural intensification with a focus on resilient horticultural production and processing for urban, peri-urban and rural dwellers. • Improving access to finance for climate resilience through awareness on climate change and climate variability for financial institutions and vulnerable groups. • Multi-stakeholder exploration of urban livelihood strategies to strengthen adaptation to climate change and climate variability. Selection of the themes was based on the following criteria:	1 2 3
Activity 2.2 – Participatory development of action research strategies for strengthening interdependent urban and rural communities' agricultural, food and energy security strategies. *Method finalized -m8, action research plans collaboratively*		1 2 3

developed and reported on m12.	- High relevance to local government and the vulnerable communities.	
Activity 2.3 – Participatory analysis of the opportunities and barriers to adaptation or system transformation; ITP demands of the different key stakeholders, and factors influencing behavioural change regarding their service provision. *Exploring and building scenarios of differing stakeholder groups and sharing these to identify action research strategies. Report – m12.*	- Direct evidence of rural urban interaction. - High indication of adaptation to climate change and climate variability. - Cross cutting across sites at national and regional level. - Linkage with the rural project. - Ability to show impact within two years This participatory analysis process has continued through the project's work with peri-urban communities, in identifying the technologies to test in the learning plots.	2 3
Activity 2.4 – Participatory development of action research strategies for strengthening interdependent urban and rural stakeholders capacity to support community adaptation of their agriculture, food and energy innovation systems to CC&CV. *Analysis, workshop & report containing plans – m14.*	Three action research themes were developed in September 2010, building on the projects activities to then. However after careful planning it was evident that the projects financial resources were not sufficient to support three separate action research themes so the project team decided to combine the three themes as much as possible. Further preliminary field work was done to select the focal communities to work with, and community baseline studies were undertaken to understand their horticultural strategies and challenges.	2
Activity 3.1 – *Urban and rural communities*: Implementation of the action research strategies developed in 2.2 (Yr 2 &3). *Urban and rural communities are voluntarily involved in and can describe their action research activities by month 18, and by month 24 have evaluated the different aspects of their action research, and used this to plan the following years action research activities. At least two media reports based on the communities' action research in each country by month 24, and a further two by month 36. Project reports capturing the implementation details and process by month 20 and 36.*	**Tanzania:** In March 2011, the Tubadilike farmer learning group (initially comprised of 21 members, some members of SACCOS and others non-members, membership is now 7W,8M) was formed in Ihumwa village, Dodoma Municipal to work with the project researchers and other key stakeholders such as Agricultural Extension Staff and VIMI SACCOS staff to collectively plan their first cycle of learning plot activities. [Note: no farmer groups existed so the project helped individual vegetable growers to form themselves into a group]. The experiential group learning process has focused on experimenting with different agronomic practices (e.g. pre-planting manure incorporation, different varieties, improved seed bed preparation methods, different pesticide applications) to see whether they could help these horticultural farmers increase the resilience of their agriculture in the face of CC. Each experimental cycle takes about 2 months, so the group has the opportunity of learning from several action research cycles of experimentation each year. They have also begun testing alternative cash crops such as sunflower, evaluating the performance of different varieties and different tillage methods. The farmers were trained on process documentation in order to capture various project activities including interventions in the learning plots. A process documentation guide was prepared in Swahili and shared with farmers. In May 2011, a stakeholder training on the science of CC&CV and adaptation was conducted for participating farmers and key stakeholders. In August 2011, these farmers visited NaneNane (the annual agricultural show) as a group and found out about other horticultural production practices which they then included in their trials. Two new farmer learning groups started after Nane Nane, Mshikamano (Ihumwa village; 9W, 4M) and Tabianchi (Mtumba village; 9W,6M) in Dodoma region, and tested similar horticultural practices in their group learning plots. Two additional horticultural learning groups were started in November 2011 in the Southern Highlands, Muungano (Mjimwema village; 15W, 7M) and Mshikamano (Imalinyi village; 9W, 9M). **Malawi:** In February 2011, the project identified two farmer groups to work with in Ntwana village, Chikwawa district. One of the farmer groups (Tigwirizane (4M; 20W)) had been previously supported by an EU project and the other (Chiyanjano	2 3

	(11M; 10W)) had not. These groups each established collective horticultural learning plots and together with researchers from Bvumbwe Agricultural Research Institute and extensionists they experimented with the use of compost, industrial fertilisers, burning of soils prior to bed preparation, use of mulches, irrigation scheduling, business planning, staggered planting to improve supply stability, and tower/vertical garden farming. Tower gardening has been found to be useful for those with limited land, limited access to irrigation water, and after the initial set up can be managed by those with physical disabilities. The crops they chose to work with included rape, tomato, onions, maize, mustard, cabbage and green beans. The learning groups received training on CC science (by Malawi Dept of CC and Met Services), entrepreneurship skills (by Young Enterprises) and record keeping (by project team), and they visited an existing and successful horticultural group (Zakudimba cooperative) and horticultural activities of Bvumbwe research station. In Sept 2011, the project scaled out the activities to two farmer groups in Sitolo village, a sub-humid area in Mulanje district. Again, one farmer group Tikondane (15W, 10M) had previously been supported by another project, while the other group (Zomera (7W, 18M)) had not. These farmers chose to experiment on similar crops to those in Ntwana village, and the same training and visit experiences were organised for them. In both districts the farmers have started applying the learning from the collective learning plot in their own fields. Outside farmers are also adopting some of the practices. In Ntwana village one of the groups has established a market with a district level hotel and now supplies their high quality vegetables to them. Vendors have also been buying their vegetables wholesale from the plots.	
Activity 3.2 – *Urban and rural communities:* Monitoring of the action research strategies, and sharing of learning re practice and process. *Indicators identified by communities and agreed on by month 15, journal keeping culture introduced by month 13. These progress and outcome journals used to create 6 monthly reports on process and practice learning from different perspectives.*	The farmer learning groups received training on process documentation and are keeping records of their group and individual experiments, the learning that resulted and their ideas for further experiments. The project team has been involved in regularly supporting and monitoring the field activities, and is also documenting the learning from their own perspectives. The farmers are being asked by their neighbours to train them on these new horticultural agronomic practices and this has been happening independently of the project and within and between villages. Local language learning plot info posters were developed in Tanzania to help explain the aims and process to their visitors. Some farmers in Malawi have created information labels for the different technologies and varieties that they have been testing. During the 2012 Learning Visits, the project team documented the action learning achievements and challenges from different stakeholders' (including the famers in the learning group) perspectives. The outcome mapping progress markers were also revisited to look at what behavioural changes were taking place. It should be noted that a significant number of the peri-urban vegetable producers around Dodoma municipal are women and often female headed households; they make up ≥50% of the group members and have seen significant livelihoods improvements already from their involvement despite the very short activity period (~9-18months). The chairman of one of the groups is a wheel chair user, and has been actively participating in the field learning plots. Most of the farmer members felt that the learning they had gained from being involved in the learning groups had already helped them to move from the poor (N.B. not extremely poor) to middle wealth groups in their community. Similarly in Malawi women are involved in the horticultural learning plots, and in all the groups >50% of the members are under 30 years old. The additional income the group members have earned from their improved horticultural practices (e.g. one farmer explained he will now earn MKw1 million/year from his vegetable production while prior to being involved in the learning group he earned only MKw30,000 in a year) – such cases are being disseminated by the National media including through TV and cartoons in newspapers. Farmers have been using their extra income to invest in their horticultural activities and to diversify their activities e.g. developing fish ponds and piggeries.	2 3

Activity 4.1 – *Local Government and other key stakeholders*: Implementation of the action research strategies developed in 2.4 (Yr 2 &3). *Local govt staff and other stakeholders can describe their action research process and findings, and have progress reported on them by months 18, 24 and 36.*	Local government officials (e.g. ward councillors) and village and district level extension workers were involved in the field action research at the learning plots. Other key stakeholders such as met officers, village based savings and credit, stockists, media etc have been involved during CC science and adaptation training and exposure visits, and in Malawi have been visiting the learning plots and responding to the group members emerging demands. The learning group farmers have made use of their trips to agricultural shows, existing horticultural cooperatives and fruit and vegetable processors, and Bvumbwe research station to interact with new stakeholders and learn about new horticultural practices. In Ntwana village, the cane sugar company constructed a permanent well for Chiyanjano group after admiring their efforts and produce.	2 3
Activity 4.2 – *Local Government and other key stakeholders* Monitoring of the action research strategies, and sharing of learning re practice and process. *Self identified indicators by m15. Journal keeping culture introduced by m14. Progress & outcome journals used to create 6 monthly reports on process & practice learning from different stakeholder perspectives.*	The project's situation analysis and proposed action research themes and approach were presented to the NCG. The project flyer has been updated regularly, 2009, Nov 2010, June 2011, June 2012. The 2012 learning visit in Central Tanzania found that whilst a number of non-farmer stakeholders had willingly been involved during the SSA, and various training seminars – it was challenging to get them to continue following up on the projects activities or visiting the learning plots even if nearby. Stakeholders such as ward level extensionists, village based SACCOS staff and some stockists had remained aware of the project's activities and visited the learning plots. The Hombolo researcher's close and particularly the hands-on field involvement with the farmer learning groups' activities was greatly appreciated by the farmers. In the Southern Highlands Zone of Tanzania, the two learning groups started in Oct/Nov 2011, and whilst the community development and extension officers were involved during the projects organised training and monitoring activities, there is no evidence of them having visited the learning plots or shared information about them at any other time. In Malawi, the stockists, DALDO, crops officer, section and village level agricultural extension, local NGO (CAVWOC, Chikwawa) have been involved during the planning, implementation, monitoring and evaluation of the field learning activities, in addition to the project team members (NAREC, Bvumbwe, CURE). The Media link people have visited the learning plots during field days (Yr2, Yr3) and attended the NCG meetings, and the projects activities have been featured on a new environmental TV programme in addition to a radio documentary. The DALDOs office incorporated additional visiting of the learning plots into their own work programme, while the met office complained they did not have the resources to do this.	2 3
Objective 3. To learn and share lessons (through process documentation) for scaling up successful strategies for strengthening capacity at individuals, organizational and systems levels within the interdependent agriculture and food innovation systems in linked urban and rural settings to adapt to the challenges and opportunities brought about by CC&CV.		
Activity 5.1 - Iterative co-development of a project CKSL plan by a group representing the key stakeholders. *CKSL plan m10, reflected on & developed till m36.*	The project developed a Communication, Knowledge Sharing and Learning plan (CKSL) in Sept 2009 and it has been adapted as the project has continued.	1 2 3
Activity 5.2 – Implementation of the project communication, knowledge sharing and learning plan. *Range of CKSL outputs developed & shared, & feedback process to inform reflective learning from m10-36.*	Email, annual meetings and joint field work have been the main methods of communication between the project team members. The project developed a website www.ccaa-urban.or.tz Various stakeholder meetings (e.g. SSA mini-meetings; NCG meetings; CC awareness stakeholder meeting; field, agricultural shows, research station and existing farmer group visits; trainings) have provided opportunities for interaction between the different stakeholders. However the Tanzanian learning visit revealed that more information and updates on the project's activities would have been appreciated by some key partners (e.g. district extension horticultural specialists). The experience gained during the Rural CCAA project on the use of video	1 2 3

	documentation has been relevant for this project, although the Malawi team have yet to receive any formal training in it. Whilst regular footage of the process has been captured, the challenge remains to edit this footage into a usable form.	
Activity 5.3 – Recorded learning / monitoring of the different processes and outputs of the CKSL plan in order to keep changing it based on experiential learning about best practice. *Regular journal keeping on feedback and suggested changes from m10-36.*	Process documentation has been a major part of the projects activity's by the project team and the farmer learning groups. Not only does farmer learning group process documentation help the project team develop a deeper understanding regards important lessons, achievements, problems and existing needs, it has also been greatly appreciated by the farmers. These farmers have also started keeping records of their own horticultural farming activities and explained that this has helped them understand their harvesting periods during different seasons of the year much better which helps with their market supply planning and negotiations, it has also allowed them to compare their yields more accurately and calculate their profits.	2 3
Activity 6.1 – Iterative development of OM, to track the project's contribution to changes in behaviour of the different key stakeholders within the projects sphere of influence. Develop Vision, Mission, O. Challenges, Progress markers, Progress journal and O. journal, Monitoring plan & Evaluation plan. *Completed OM - m14, & 6m reports.*	The monitoring and evaluation plan was developed in Year 1, which built strongly on the detailed Outcome Mapping (OM) process and learning from the sister CCAA rural project. The project team's outcome journal has been updated on a 6 monthly basis. Progress by the other stakeholders/ boundary partners was monitored during the 2012 learning visits. However the farmer and extension workers in the learning groups have also been producing ongoing progress reports as part of their process documentation activities.	1
Activity 6.2 – Implementation of the OM through journal entries, revisions and sharing of learning. *Iterative development and reflective learning evident in 6 monthly progress reports.*	The OM was used with the different boundary partners during the 2012 learning visits, to learn about their (expect, like and love to see) changes in behaviours. Whilst findings differed by BP, the farmer learning groups had achieved a great deal of the "expect and like to see markers", and had made progress on some of the love to see markers. The project team has updated its OM journal entry every 6 months during the donor progress report activity. Experience gained from the PAR workshop in Ghana in Year 1 highlighted the usefulness of undertaking process documentation as part of the project's M&E activities. Hence in year 2, the project concentrated on applying the process in all field activities including workshops (refer to process documentation country reports). This assisted in reflecting and re-planning project activities.	2 3

Project outputs and dissemination

In this report, the project outputs are directly achievable products of the project's completed activities such as consultations meeting reports, survey reports, training reports, field visit reports, policy briefs, journal articles, research papers etc. Other means used to disseminate information included the project website and radio and TV. It should be noted that dissemination and discussion of the findings was also undertaken during stakeholders' and farmers' training sessions. The learning visits that were being conducted to monitor progress also provided opportunity to discuss the outcomes of the interventions. Table 3 provides a list of different outputs produced by the project according to timeline. The categories of outputs presented include:

- Planning and Information sharing
- Knowledge creation (new knowledge embodied in forms other than publications or reports: new technologies, new methodologies, new curricula, new policies etc.); and
- Training (short-term training, internships or fellowships, training seminars and workshops, thesis supervision etc.).
- Information sharing and dissemination (reports, publications, conferences, Web sites etc);

Table 3. List of major outputs

Type of output	Title of the output	Date completed
I] Planning and Information Sharing		
Workshop/ Meeting Reports	Project inception workshop report	November 2009
	Planning meeting report	February 2010
II] Knowledge Creation		
Research Reports	Tanzania Reconnaissance Survey Report	September 2009
	Malawi Reconnaissance Survey Report	September 2009
	Tanzania Situation and Scenario Analysis Report	September 2010
	Malawi Situation and Scenario Analysis Report	February 2011
	Tanzania Community Baseline Survey Report – Central Zone	January 2011
	Malawi Community Baseline Survey Report	February 2011
	Tanzania Community Baseline Survey Report – Southern Highland Zone	November 2011
III] Training (short – term)/ Stakeholders workshops/ Seminars		
	Tanzania: Stakeholders Training Workshop on Climate Change and Variability & Field Visit to CCAA Rural Project Site in Dodoma, Central Zone	May 2011
	Report on Ntwana village based seminars on climate change and variability, entrepreneurship and field trip to Bvumbwe by Ntwana Villagers	May 2011
	Tanzania – Nanenane Report: Study Visit and Farmers Trainings Sessions Report in the Central Zone	August 2011
	Report on Field Trip to Bumbwe Research Station and Zakudimba Cooperative and Trainings in Climate Change and Entrepreneurship for Sitolo Village, Mulanje District	October 2011
	Tanzania: Stakeholders Training Workshop, Exchange & Field Visit Report in Njombe, Southern Highlands of Tanzania	January 2012
IV] Information Sharing and Dissemination		
National Consultation Group Meetings Reports	Tanzania National Consultation Group Workshop Report – Bagamoyo	September 2010
	Malawi National Consultation Group Workshop report – Blantyre	November 2010
Tanzania Process Documentation	Tanzania – Process Documentation for Identification of Learning Groups, Plots and Planning for Implementation of Action Research in Dodoma, Central Zone	May 2011
	Tanzania: Process documentation report on progress in implementation of Action Research in Dodoma, Central Zone	June 2011
	Tanzania – Field Report on Planning and Implementation of Action Research in Njombe, Southern Highlands Zone	November 2011
	Tanzania – Process Documentation Report – Njombe Southern Highland Zone	November 2011
	Tanzania – Process Documentation of 3 Learning Groups (Tubadilike, Mshikamano & Tabianchi), Dodoma, Tanzania	December 2011
	Tanzania – Process Documentation Report for Implementation of Action Research – Central Zone	April 2012
	Tanzania – Process Documentation Report for Implementation of Action Research – Southern Zone	April 2012
	Tanzania – Learning Visit Report	May 2012
Malawi Process Documentation	Report on group formation and Participatory Identification of learning plots in Ntwana Village	March 2011
	Report on Group Formation and Baseline for Ntwana Village, Chikhwawa District	March 2011
	Implementation of Action Research in Ntwana Village, Chikhwawa District, Malawi - Process Documentation Report, First Learning Visit	June 2011
	Implementation of Action Research in Ntwana Village,	July 2011

	Chikhwawa District, Malawi Field monitoring visits Report – Farmers exchange visits and mini field day Report	
	Implementation of Action Research in Ntwana Village, Chikhwawa District, Malawi Field monitoring visits Report	August - December 2011
	Report on Group Formation and Baseline for Sitolo Village, Mulanje District	Sept- Nov 2011
	Progress of Field activities and Tower Gardening Training Report for Sitolo Village, Mulanje District	December 2011
	Implementation of Action Research in Ntwana Village,Chikhwawa District & Sitolo Village, Mulanje District, Malawi - Process Documentation Report, Second Learning Visit	December 2011
	Implementation of Action Research in Ntwana and Sitolo Villages, Chikhwawa and Mulanje Districts, Malawi Field Monitoring and Planning Visits Report	March 2012
	Malawi Learning visit report for Ntwana and Sitolo villages	
Journal papers	Two journal articles in preparation How resilient are urban food systems? The potential of peri-urban horticulture in CC adaptation	
Chapters in Workshop Proceedings/Book	Knowledge Sharing And Institutional Capacity Building For Climate Change Adaptation: Contribution to the CCAA Book: Section 1: Chapter 2	March 2012
Project fliers	Project brochures/poster (English, Swahili & Chichewa) Revised Project Brochure	December 2009
	Project brochures/ Posters/ Roller Banner (English, Swahili)	May 2012
Other Project documents/links	Project communication, knowledge sharing and learning plan Monitoring and Evaluation Framework Plan Project website (www.ccaa-urban.or.tz)	September 2009 December 2009 2009
Newspapers articles	Mpotazingwe, M., (2010). Climate Change Effects Haunting Malawi [NCG meeting – Progress of CC Adaptation Rural Project and Introduction of Urban Rural Project], Daily Times, 30 November, 2010, Malawi.	November 2010
	Kanjo, M., (June 2012). Wonders of Vegetable Farming: National Newspaper. 7th June 2012.	June 2012
Radio and TV Coverage	November 2010. CCAA Rural Project's Malawi NCG Meeting and introduction of Urban Rural Project. Malawi Broadcasting Television, News, 26 November 2010.	November 2010
	May 2012. News Bulletin – vegetable gardening and climate change adaptation at the rural urban interface, *Malawi Broadcasting Radio 2*. Noon and 6pm, 30 May 2012	May 2012
	May-June 2012. News Bulletin – vegetable gardening and climate change adaptation at the rural urban interface in Chikhwawa and Mulanje. Malawi Broad Casting Television News Aired more than 6 times (in Chichewa and English) between 31st May 2012 – 1st June 2012	May – June 2012
	June 2012 News Bulletin – Vertical/Tower Vegetable Gardening and Climate Change Adaptation at the Rural Urban interface in Chikhwawa and Mulanje. Malawi Broad Casting Television News Aired for 6 times (in Chichewa and English) between 11th and 12th June 2012.	June 2012
V] PhD and MSc Training		
	Noah Makula Pauline (PhD Thesis). "*Living with Climate Variability and Change*" – Lessons from Tanzania	[on-going]
	Brown Gwambene (PhD.) Thesis. "*Assessment of Agricultural Dynamics in the Context of Climate Variability in Southern Highlands of Tanzania*"	[on-going]
	Nico Malik (MSc. Thesis). "*Analysis of Land Use/Land Cover*	[on-going]

	Changes – Implications on Natural Resource Management in the Great Ruaha Basin - Tanzania"	
	Lucy Kassian (MSc. Thesis) "*Investigating the Socio-economic and Environmental Implications of Valley Bottom Farming as Adaptation Strategy to Climate Change – A Case of Ruaha Sub-catchment Area*"	[on-going]
	Ruth Kalinga-Chirwa (MSc. Thesis). *"Linking Rainfall Variability and Irrigation to Malaria Incidences in Mphampha and Mpasu Villages in Chikwakwa District – Malawi"*	[on-going]
	Emmanuel C. Mkomwa (MSc. Thesis). *"Assessing Indigenous Knowledge Systems in Climate Change Adaptation in Mbewe EPA, Chikwawa District – Malawi"*	[on-going]

Capacity building

UNDP[5] defines capacity as "*the ability of individuals, institutions and societies to perform functions, solve problems, and set and achieve objectives in a sustainable manner*." Capacity development/building is thereby the process through which the abilities to do so are obtained, strengthened, adapted and maintained over time.

The project's capacity building interventions strived to build mutual learning among the project team and diverse stakeholders who together comprise the agricultural and food innovation systems in the project's interlinked urban and rural settings in order to adapt to the challenges of climate change and variability.

The project forged learning alliances among key stakeholders using the innovation systems thinking. The aim was to maximise opportunities for horizontal and vertical learning between project partners, target beneficiaries and other stakeholders. The project targeted agricultural intensification, with emphasis on resilient horticultural production and processing for urban, peri-urban and rural dwellers.

A key element of capacity building is the participatory nature of the action-research process during implementation. The active involvement of focal urban and rural communities and other stakeholders in the action-research process offered opportunities for continuous reflection and documentation along the project cycle. This contributed to improved capacity of farmer groups in developing and practicing strategies for reducing their vulnerability to climate-related risks in the interdependent urban and rural agricultural and food systems.

Capacity building activities were undertaken at various stages of the project cycle, from situation analysis and stakeholder consultations, understanding of urban-rural interdependence and vulnerability to CC&CV; development of participatory learning approaches and tools for use with diverse stakeholders; differentiated analysis of coping and adaptation strategies; action research of different CC&CV adaptation strategies; outcome mapping; development and implementation of communication, knowledge sharing and learning strategy (including policy engagement), participatory scaling-up strategies; as well as during the documentation process and preparation of various project reports.

The capacity building interventions undertaken and associated outcomes are summarized below:

[5] UNDP (2007) Capacity Assessment Methodology User's Guide. Capacity Development Group Bureau for Development Policy.

Inception workshop, Situational and Scenario analyses:

The Inception workshop enabled the team members to collectively understand the project aims and objectives and their respective roles as well as instil a sense of ownership of the project. The situation and scenario analyses involved a wide range of stakeholder categories including separate focus group discussions with men and with women. The process entailed analysis of focal peri-urban and rural communities' agriculture and food interdependencies and perceived vulnerability to CC. Special attention was given to youth such as market porters; and women involved in various livelihood activities such as food vendors and vegetable sellers. Through these consultations, the team learned more regarding perceptions of climate change, and stakeholders took the opportunity to reflect deeply on how climate change and variability is affecting their livelihoods.

Stakeholder consultations involved all project team members and other actors in learning and building common understanding on CC issues and understanding of the inter-dependencies of the rural-urban agriculture and food innovation systems.

Village & stakeholder seminars (CC science, adaptation strategies, record keeping, entrepreneurship and group formation & dynamics):

In planning action-research actions, farmers participated in selection and prioritizing of the technologies to be experimented. A series of action-training activities using seminars/ workshops were undertaken involving target farmers groups and other relevant stakeholders. These activities enabled stakeholders gain a general understanding of the project focus and its orientation, its objectives and expectations. The workshops were also used to obtain views and expectations of the beneficiaries, establishment of target groups and in the on-going process of implementing action-research interventions in the field.

Given that the project aimed at improving capacity to adapt to climate change and variability, the Participatory Action Research approach was used. The action research themes were developed from a sequence of reconnaissance surveys, situation and scenario analysis, consultative meetings, field visits and collective planning processes with a view to enhancing the horticultural enterprise and related livelihood opportunities within the rural-urban interdependency context. The action-research activities provided an opportunity for shared learning, reflection and documentation by the project team and target communities, including farmer groups and other village members. As a result of active farmers' participation in the project, there is an improvement of horticultural crops production, livelihood and food security to the extent that other farmers are learning from them, increased household income through the learning acquired; enhanced capacity to experiment with new innovations; increased knowledge on agriculture and climate change and adaptation; increased interaction with other stakeholders; introduction and use of new adaptation strategies to the impacts of CC&V, as well as acquiring knowledge on rain water harvesting and environmental management/conservation.

Farmers also learned about the impacts of Climate Change on Agriculture and Food Security such as the unpredictable start and end of the rain season, increased incidence of pest attacks, resulting from increase in temperature, negative impacts of climate change on supply, quality and demand for water. In addition, farmers learned the vulnerability of rural communities and agriculture to the challenges of CC&CV in Tanzania and Malawi, as well as various adaptation strategies for agricultural production such as planting early maturing crops, planting of drought-tolerant crop varieties, improved water and soil moisture conservation methods, proper application of manure for improving soil fertility and soil moisture retention, crop diversification and using water harvesting and techniques.

The workshops were also used to build local capacity in group dynamics. Farmers were able to form groups and elect the leadership as well as choose priority options for learning through action research. Target farmers were also trained on Climate Change and Adaptation to equip them with

basic concepts regarding implementation of field-based Participatory Action Research (PAR); record keeping through process documentation and introductory entrepreneurship. A "Process Documentation Guide" used in the training was translated into Swahili language and shared with farmers.

Learning plots – mother and baby plots:

Implementation of action research used the 'learning plots' approach. The farmer groups identified and volunteered land for learning plots and provided the manpower needed for both the group and individual farmers' plots. The learning plots were used as venues for training as well as demonstrations where other farmers not participating in the project would learn.

Although the focus of action-research across sites was on improvement of horticultural production there was variation in the specific technologies promoted, from improved soil moisture conservation (in Central Zone), to testing of different varieties of tomatoes in Southern Highlands, Tanzania. In Malawi, the promoted technologies focussed on increasing productivity and sustainability. The horticultural crops used include *Amaranthus*, Chinese cabbage, tomatoes, green beans and onion. The improved management practices used across sites included seedbed preparation, proper spacing, proper application of chemical fertilizers and use of farmyard manure to enhance soil moisture conservation, and proper application of pesticides.

Study tours and exchange visits:

Capacity building was achieved through organising study tours/ field visits and exchange visits to facilitate horizontal farmer-farmer learning.

The project facilitated farmers from three groups at Ihumwa and Mtumba villages to participate at National Agricultural Exhibitions (NaneNane) in Dodoma in 2011, as well as visits to research stations (in Malawi) and farmers' co-operatives and between the farmer groups themselves, including organising field visits. This fostered improved learning of innovative horticultural production techniques relevant to CC&CV adaptation and linked participating farmers with potential stakeholders to enhance consultations and interactions for strengthening their capacity to adapt to CC&CV.

Farmers from Ihumwa village visited a farmer group in Chibelela village which participated in the previous CCAA funded rural project. The visit enabled farmers to learn about the benefits of group organization. Also, representatives of farmer groups in Ihumwa and Mtumba in Dodoma visited Njombe in Southern Highlands where they were able to exchange ideas and learn from each other, with farmer groups from Imalinyi and Mjimwema and representatives of a farmer group involved in the previous CCAA funded rural project from Nyombo village.

These interactions have stimulated farmers' interest for continued learning. From the interventions, farmers were able to learn on the concepts of Climate, Climate Variability and Change, the causes of climate change and the implications of climate change on frequency of extreme weather events such as floods and droughts, distribution and prevalence of weather induced pests and diseases.

Learning visits and use of participatory video:

Two learning visits were done in both Tanzania and Malawi with the aim of capturing perspectives of the project actors on the process and products of the project. The visits facilitated shared learning associated with the action-research activities among the project team and farmers groups, and the participatory assessment of the outcome mapping indicators with project boundary partners. The visits involved project team, target farmer groups, and other boundary partners including extension staff (ward and district), village/ward leaders, and stockists.

Video was also used as a tool to aid capacity building and learning. In the project, video was used by farmers and project teams in both countries to facilitate sharing of information and document the learning process.

Institutional reinforcement and sustainability of the research organization (new equipment, training, improved administrative skills, lessons learned etc.):

The project has enhanced the capacity of collaborating institutions to undertake research in various ways, including the acquisition of knowledge and experience as well as research equipment and facilities. The research equipment include five lap-top (4 for Tanzania, 1 for Malawi) and two desk top computers (for Malawi), three flip video cameras (for Tanzania), two digital cameras (one each for Malawi and Tanzania) and office furniture for Malawi. It has also bought four treadle pumps (in Malawi) and eight knap-sack sprayers (4 in Malawi and 4 in Tanzania) for supporting action-research activities by farmer groups in both. In Dodoma the municipal council provided two treadle pumps for participating farmer groups in Ihumwa village, while INADES Formation provided training manuals on group dynamics. The farmer groups volunteered land for the learning plots. This implies that farmers have recognised the value of research and the need for availing resources such as land for communal learning.

Increased research or administrative skills of the researchers involved:

The project has brought together a trans-disciplinary team of researchers from Tanzania, Malawi and U.K., and from the academic, public research, and private domains. This has facilitated building of synergies and complementarities in a learning alliance and innovation system approach (understanding the challenges and its application). The team has gained knowledge and capacity in applying new participatory approaches in undertaking action-research including PAR, Process documentation and Outcome Mapping for monitoring and evaluating the process (attitude and behaviour change).

By using the learning platforms, researchers' skills in preparation of project reports have improved. The project has produced a number of reports and publications, including progress reports, process documentation and learning visit reports, technical reports, policy briefs and drafts of journal papers. Some team members have participated in writing a chapter in a book to be published, titled "*Institutional Adaptation to Climate Change: Can Africa Meet the Challenges*".

Short-term training workshops provided by IDRC were also used for capacity building of members of the project team (both Malawi and Tanzania). Five members of the team participated in training workshops on:

- Climate Risk Assessment [*attended by Ms Madaka Tumbo (Tz) in Kenya*]
- Outcome Mapping [*attended by Mr Evans Mwathunga (Mw) in Senegal*]
- Gender Mainstreaming in Adaptation Strategies [*attended by Ms Stella Ndau (Mw) in Kenya*]
- Participatory Action Research (PAR) Methodology [*attended by Dr Emma Liwenga (Tz) and Mrs Miriam Joshua (Mw) in Ghana*]
- Policy workshop organized by the CCAA Team dealing with policy issues. The aim of this workshop was to share lessons among projects and developing a strategy for policy engagement.

Capacity building was also achieved through engaging young research scientists in project activities in Malawi and Tanzania. This includes full time involvement of one research assistant pursuing PhD studies in one of the project's target locations, and capacity building on climate change for researchers pursuing MSc. degrees who participated in some project activities as part of their research work (see Table 3 for details).

Contribution to capacity-building of women or marginalized social groups:

In implementing the project, gender was duly considered by inclusion of both men and women in all categories of stakeholders as shown hereunder. Women participation averaged 55%. While amongst the beneficiaries the percentage participation was 57% women and 43% men, in the case of the project team it was 50%. The marginalized social groups participated in the project. This includes the elderly, disabled (e.g. Chairperson of Tubadilike farmer group in Ihumwa), youth even school children (in the case of Malawi).

Table 4. Gender breakdown of BPs working with the project

Boundary Partner		Men	Women
Farmers	Tanzania	34	49
	Malawi	43	52
Extension Staff	Tanzania	1	7
	Malawi	7	2
Stockists	Tanzania	-	2
	Malawi	1	1
Media	Tanzania	2	3
	Malawi	5	1
NGOs	Tanzania	1	-
	Malawi	2	1
Research Team	Tanzania	5	2
	Malawi	3	5
	U.K.	1	2

From farmers' perspective, involvement in action-research (learning by doing) has built their capacity to experiment and innovate. It has also contributed to behaviour change, resulting in increased interest and involvement in testing different interventions on different crops, and thinking about further interventions they would like to test. These include field testing various agricultural interventions in the respective sites, establishment and management of mother plots/ learning plots where collective learning is done as facilitated by project staff and agricultural extension officers in the respective areas. It has also triggered farmers to replicate lessons learnt from collective learning/ mother plots in their individual/ baby plots, as well as influencing other farmers both within and in nearby villages to adopt the best technologies. The training workshops and exchange visits have contributed to increased farmers' understanding of CC&CV issues. The exchange visits and field tours to other organizations also strengthened the ability to test various agricultural adaptation options, including the relevance of farmers learning groups in strengthening adaptation.

In general, the capacity building interventions have contributed to helping the poor farmers, women and the marginalised social groups, move up the social ladder (social mobility which they explained was linked to them now being able to access better food, have more funds for educating their children, invest more in their horticultural activities and set up other small businesses), as a result of getting involved in project activities.

This is measured by the farmers participating in the project who reported that many of them have now moved to the middle income category as a result of the increased horticultural yields and incomes, as described earlier they explained they could now access better food, have more funds for educating their children, invest more in their horticultural activities and set up other small businesses. It has not been measured quantitatively.

Project management

The key project collaborators, participating institutions and other stakeholders involved in this project are sketched out in Figure 1 below. The lead institution, IRA, managed the project and, like NAREC, was responsible for management, facilitation and coordinating M&E in their respective countries. NRI facilitated and supported the management processes of IRA and NAREC, and brought innovation systems thinking, multi-stakeholder learning processes, trans-disciplinary action research, resilience theory, urban and urban-rural research and participatory learning and monitoring skills. The project facilitation team supported an iterative process in which trans-disciplinary teams at intermediate and local level visualised, reflected on, generated and tested alternative approaches to adapting to CC&CV that offer immediate and longer term benefits to various stakeholders in the interdependent urban and rural agriculture and food innovation systems. These teams / learning platforms included local government, government agricultural extension organizations in focal rural and urban sites, agricultural research institutes (ARI Uyole and Hombolo, Bvumbwe Agricultural Research Station), NGOs (INADES Formation Tanzania, CURE), small and medium scale enterprises (e.g. Mariet Foods) and informal community groups.

This project built on a previous CCAA project's National Consultation Group (NCG) whose perceptions of issues, causes, implications and solutions can play a pivotal role in public service, commercial and policy decision making. Roles and responsibilities of trans-disciplinary teams for each activity were developed and agreed upon at the inception workshop. What worked well and what worked less well regards project management is described in Table 5 below.

Figure 1. Project partners and other key stakeholders and stakeholder groups involved in the project

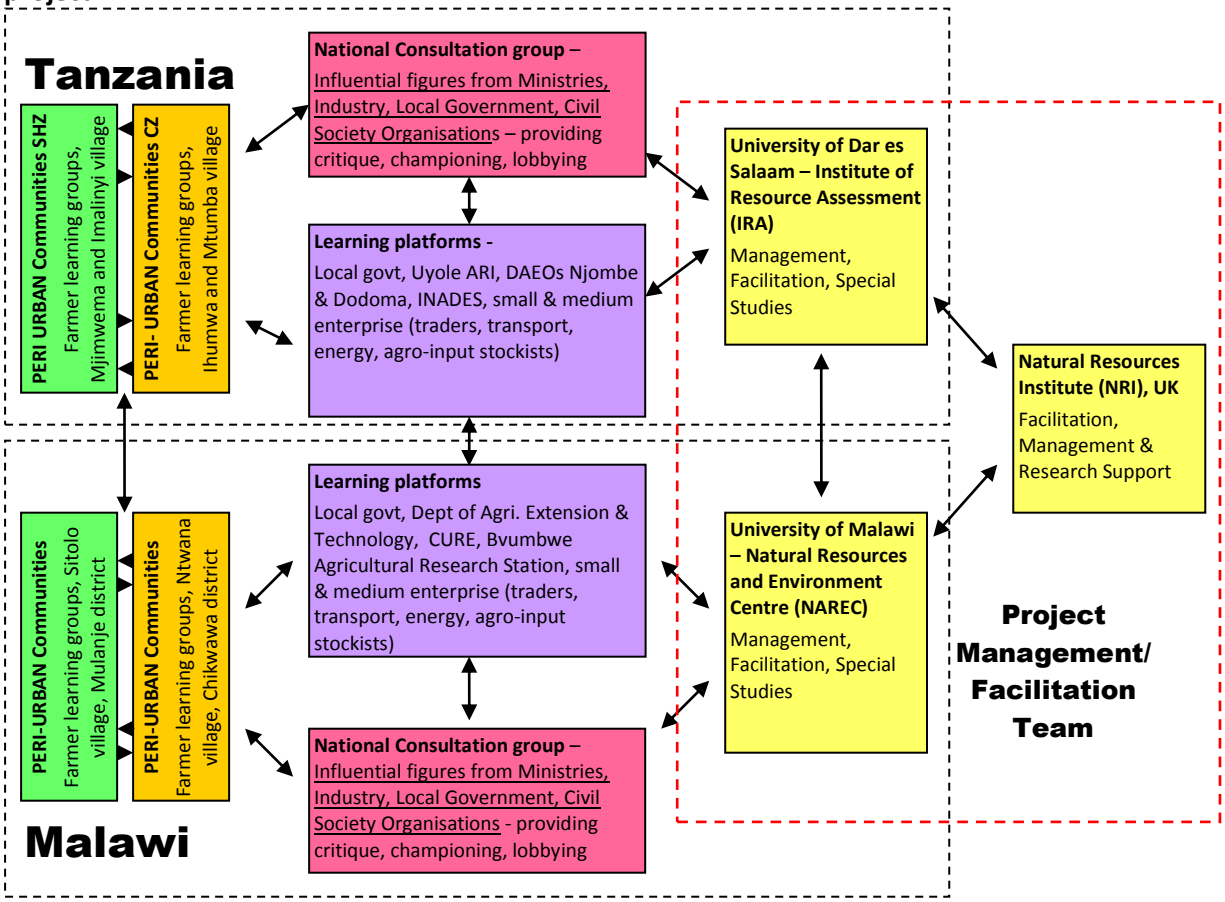

Table 5. Project management: What worked well and what has worked less well?

Topic	What worked well	What worked less well
Communication	• Communication within the project team has been very good • Links with other CCAA projects was good	• Communication and linkages between stakeholders could have been much better by regular follow up.
Participation	• High participation at community level • Participation by Ministry of Agriculture, Met Office (Tz and Mw) and Media (Malawi) at national level was fairly good	• Participation at district level was variable
Finance	• Transparency in internal disbursement of funds	• Financial disbursement by IDRC has been delayed at times
CCAA coordination and follow-up	• CCAA East Africa and Africa coordination and follow up was good	• None reported
Project duration	• None reported	• Project duration was too short for this type of action research project (should be minimum of 5 years)
Training	• CCAA Training courses were relevant	• Lack of advanced notice for CCAA trainings • CCAA training course topics were identified in a top down way i.e. there was no consultation with the projects about training needs
Scientific management	• Action research worked well at community level with farmers and stockists. The reflection stages were particularly appreciated by both farmers and researchers. • Researcher – farmer interaction resulted in choice of best bet technologies which brought very immediate benefits e.g. doubling vegetable yields, reduce water use.	• Limited non farmer stakeholder engagement in action research, • Some farmers needed more capacity to compare treatments

Impact

Impact may be considered in terms of reach (reception and use of the knowledge produced) and impact (influence of this new knowledge on decisions or on development more generally). This is considered for each of the project boundary partners at individual or organizational level. We then consider any impacts on the overall agricultural innovation system.

The boundary partners were: Farmers, Researchers, Extension, Input Stockists, NGOs, Media, Met Office, NCG, local government.

General/ cross cutting

The project aimed to achieve a multi-stakeholder collective learning process. Through the project awareness on interdependence of rural and urban communities, local government and other key stakeholders and adaptation to climate change and variability effects amongst the main stakeholders has been increased within the project areas. The project team is also now much more familiar with climate change and urban issues and together with other AIS stakeholders, have a greater understanding of the significant interdependencies between rural and urban livelihoods and the impact of CC&CV. This is influencing other decisions for instance in teaching and research work and discussions that team members are involved in.

Knowledge derived from situation analysis and shared among stakeholders informed our detailed project strategy. This in turn may inform stakeholders of implications of their decisions for livelihoods of marginalized social groups. Further, knowledge on science of CC&CV strengthened the capacities of various stakeholders to better understand adaptation strategies for enhancing resilience.

Participatory action research which involved a multi-stakeholder learning approach has generated knowledge collectively to exploit synergies and complementarities in strategising the transfer and evaluation of technologies for adaptation to adverse effects of CC&CV.

Farmers

Group formation and organizational strengthening

In order to strengthen adaptive capacity, farmers were organised in groups. The farmer learning groups were strengthened with special emphasis on group dynamics, leadership and constitution development for sustainability. This exercise was geared towards empowering farmers to actively source knowledge from service providers for example, extension service, input stockists, veterinary, research and fisheries.

Through the multidisciplinary stakeholder approach, various options and strategies were developed for farmers to better adapt to CC&CV. Through experimental plots farmers whose composition included the disabled, elderly and youth acquired greater knowledge tailored on vegetable production intensification than before.

Participatory action research

Farmers underlined the importance of research/ experimentation to assess the effectiveness and performance of technologies, practices etc. For instance, the farmer groups noted that the use of improved and early maturing varieties for vegetable production resulted in high yields. Alongside experimentation, farmers noted that record keeping was important in assessing costs incurred and benefits and therefore facilitating planning for subsequent cropping seasons.

PAR revealed increased vegetable production mainly attributed to the application of improved agronomic practices in the learning plots, notably incorporation of FYM into their soils, proper spacing, mulching, weeding regimes, tower/vertical gardening, judicious application of fertilisers and pesticides. These technologies facilitated efficient water and land use which are limited resources in

peri-urban areas. Further, these best practices resulted in reduced frequency of watering and therefore more user friendly for vulnerable social groups. Improved quality of produce, early plucking and therefore increased number of pluckings of leafy vegetables due to manure incorporation and high yields in general were among other advantages realised. On the other hand, the judicious use of pesticides resulted in effective control of pests and diseases and in turn, there were limited over application and uneven spraying which causes burning of crops and may cause health problems for consumers. As a result of high crop performance in learning plots, both participating and non participating farmers of all categories (including the elderly, widows, youth and disabled) have started using these innovations in their own individual plots.

Livelihood diversification

In view of awareness of impact of climate change on crop performance alongside on-site trainings on CC&CV, entrepreneurship skills among others, farmers in the study area independently embarked on other options/enterprises to better adapt to the impact of climate change. Some of these livelihoods diversification options included new field crops (e.g. sunflower), fish farming, pig keeping and rearing of local chicken. For instance, farmers in Malawi had the confidence to demand services from service providers and acquired fingerlings and knowledge of fish farming from the Fisheries Department for free.

Of equal importance, farmer training on improved marketing and entrepreneurship strengthened their capacities to sustain supply and market their produce. Farmers have since started group savings and credit in Malawi whose training was facilitated by the NGO Centre for Alternatives for Victimised Women and Children (CAVWOC).

Researchers

The success of the project is significantly attributed to the effective involvement of the multidisciplinary composition of the research team. The knowledge shared among the research team enhanced synergies and complementarities in planning and targeting sound adaptive interventions for different social groups. For instance, in depth understanding of prevailing status of horticultural sector in farmers and market perspectives enabled them to fine tune resilient interventions. More so, screening of innovations led to the identification of best bet practices for adoption. The planning and project development and training delivery activities of all the researchers now includes a much greater focus on CC adaptation and integration of urban vulnerability issues than prior to the project. The support for the multi-disciplinary and experiential learning approach and agricultural innovation systems thinking was driven by the research team, while the experiential learning approach worked well; the other two areas still need further support to bring the theory to fruition.

Extension service

Presently, extension personnel involved in the PAR have improved ability to provide technical backstopping on vegetable production and entrepreneurship, designing and implementing learning plots which can also address the challenges of vulnerable groups, and confidence regards CC&CV knowledge and adaptation strategies. Despite the project coming to an end, District Agriculture Departments will continue working with learning groups for further agriculture initiatives. In Malawi the District agriculture Development Officer is organizing district agricultural shows whereby tower gardening will be exhibited

Agricultural input stockists

Through their involvement in the project, stockists were linked to farmers learning groups, which allowed them to identify and respond to farmer needs. For example, packaging of inputs into mini packs to allow affordability by all farmer categories including the marginalised social groups. Above all, farmer-stockist interaction provided knowledge on what to stock in relation to farmers' demand, and in one case resulted in stockists bringing the products closer to the farmers.

Non-governmental organisations

The value of NGOs was manifested through provision of trainings and training material to impart desired knowledge to strengthen adaptive capacity of farmers on CC&CV. For example, INADES (Tanzania) provided training material on group dynamics, chicken production, fish farming. The young enterprise organisation in Malawi trained the farmers on entrepreneurship skills, while the CAVOWC provided village banking skills. The various knowledge acquired by the farming communities triggered them to embark on livelihoods diversification which also provided a wider choice of adaptive approaches for selection for the vulnerable members of the society. Similarly, the participation of NGOs in this study has influenced planning and practice. For example, climate change is now part of INADES long term strategy and helped them to secure donor partner funding. INADES shared ideas with the INADES international board, which has helped to secure funding for an adaptation project. The project has helped to draw attention to existing NGO activities relevant to CC adaptation. INADES has provided training to MVIWATA (Umbrella Farmer Network in Tanzania) in response to their request. It has helped INADES to secure and implement other CC projects e.g. Linking Climate Change Adaptation and Disaster Risk Reduction with the UK Overseas Development Institute.

Meteorology services

The Tanzania Meteorology Agency and the Malawi Climate Change and Meteorological Services Department created awareness on climate science and adaptation through trainings of all key stakeholders. The acquired knowledge by various stakeholders enabled them to become more focused on the selection of climate tailored adaptive strategies for different social groups for example, tower gardens for the elderly, disabled and those with limited land. The project facilitated Met office to raise awareness amongst farmers. Met Offices now have greater awareness of farmers' interests, strategies and activities. Participation of Met officers in the project has strengthened their knowledge on enhancing knowledge on the science of climate.

National consultative group

NCG members have been involved in stakeholder workshops. In Malawi links with NCG members has led to R-U linkages issues (such as the impact of CC&V on urban and peri-urban livelihoods and need for the participatory development of relevant adaptation options) being included in the revised National Adaptation Programme of Action (NAPA).

Overall assessment

The project used a novel approach to exploring R-U linkages and CC and this was the first time such studies have been done in Tanzania and Malawi. Information was gained through the use of a participatory learning process. This has helped to raise awareness amongst local government and other stakeholders regarding urban-rural linkages in general and food and agricultural systems in particular. In Malawi, urban agriculture is to be incorporated into national (agricultural and urban planning policy for peri-urban areas) and local government (district agricultural plans) policy.

Horticultural production can be incorporated into a situation where land and water are scarce, using appropriate technologies such as tower gardens. Horticultural systems can be adapted to both improve capacity of vulnerable people and strengthen resilience of food systems.

The action research activities implemented have provided valuable outcomes. The PAR or participatory learning approaches both strengthened farmers' ability to analyze and identify ways of improving their situation and to achieve faster uptake of technologies (compared to demonstration plots for example). In Tanzania, process documentation by farmers was considered an important aspect of this process. Linking farmers to other stakeholders and subsequently empowering farmers to make their own links or contacts is a key to strengthening adaptive capacity. This changes farmers

from being passive participants to active agents with much greater ability to address their information and other needs.

The initial situation analysis activities identified a wonderful range of action research opportunities, but the project resources available meant we were only able to respond to a small number of these opportunities. The importance of developing links between urban and rural local governments was confirmed, but not achieved in this project. There is a gap between extension policy and implementation. For example, groups and participatory learning are part of national policy in both countries but implementation is limited. These and other opportunities identified could form the basis of a further action research project or even programme.

Assessment in terms of time, effort and resources

- In the first year of the project time, effort and resources focused on understanding the R-U interdependency and CC impacts context. This was essential because there was so little existing information or awareness about these topics. In the second and third years the focus moved onto implementing action research activities. Depending on stakeholders' roles, differing amounts of time were used at different points in the project life cycle.
- The project originally intended to take a rural: urban interdependence perspective, but within the time frame decided to working on peri-urban: urban interdependence, and focused on short term high value horticultural crops as opposed to a broader range of activities.
- Achieving a common understanding of the R-U linkages in the context of CC&V required engagement of different stakeholders. This was time and resource consuming since it involved a number of steps and processes e.g. building learning platforms, reconnaissance studies, Situational and Scenario Analysis and Community baselines.
- Availability of time was a critical factor influencing the effectiveness of the learning process. Those investing most time and effort were the project team and the direct beneficiaries' farmers in learning groups i.e. those who could see the clearest link between the investment in time and direct benefits.
- Horticultural systems are particularly suited to PAR as several reflective learning cycles can be achieved within one year.
- Strengthened self-organization and the ability to experiment and innovate empower farmers and in the long term create efficiencies for AIS service provision to adapt to CC&CV.
- Despite the short 3 year time frame, farmers have increased their horticultural production and incomes, having used many of the learning group technologies in their own plots, and these have been copied by other neighbouring farmers.
- The detailed but flexible project work plan allowed opportunities for reflection and redirection of the activities which increased efficiency and returns in terms of knowledge and practice on CC adaptation.
- The project aimed to gather information and facilitate behavioural change and the PAR approach used is suited to such activities.
- Delays in fund disbursement by CCAA were sometimes problematic, particularly because further transfer from Tanzania to Malawi banks can take a further month.

Recommendations

During the end of project writeshop, the project team identified the following recommendations to make to IDRC.

- Adaptation to CC&CV requires long-term investment. In funding CC adaptation projects, it is imperative to provide opportunities for longer term engagement. There was a strong case for a programme addressing strengthening adaptive capacity to climate change to be much longer.
- Training courses for project teams need to be based on participants needs.
- Due to rapid urbanization, population increase and the associated challenges linked to CC&V, it is recommended to place more emphasis on urban-based research, both in terms of resources and time.
- Multi-stakeholder involvement should be promoted given its importance in building learning platforms, including local government, NGOs etc.
- The CCAA programme is ending and has therefore not been able to make much use of the lesson learning that has come through the urban vulnerability projects. CCAA should ensure that lessons from these projects are effectively shared with other key stakeholders,
- To scale out and up the learning that has resulted requires more time, and this would help to significantly increase the returns to the investments made in the project. At local level, the scaling out will initially be through well organized field days, where the farmers show and describe their trials and learning to other horticultural farmers.
- Organizations which are leading projects, but are not in a position to borrow funds, need advances from the programme if activities are to be achieved as per the workplan. Otherwise the project's planned activities cannot be completed till the final tranche of funds arrive after the end of the project (and in the case of the CCAA rural project they arrived almost a full one year after the end of the project). This inevitably has a negative influence on the scaling up activities which are planned to happen following the learning towards the end of the projects life span, and therefore reduces the reach and impact of projects.

Appendix 1. Overview of climate trends for Tanzania and Malawi

The climates in both Tanzania and Malawi are predominantly tropical. This is characterized by a seasonal climate tied to the north and south annual movement of the Inter-tropical Convergence Zone (ITCZ). The ITCZ is marked by the convergence of northeasterly monsoon and southeasterly trade winds. In some areas of Tanzania, the migration of the ITCZ results in a double rain season: one as the ITCZ moves southwards at the beginning of summer and another when the ITCZ moves northwards at the end of summer. Annual disturbances to the ITCZ related to warmer and colder sea level surface temperatures (SST) affect the inter-annual rainfall pattern in both countries. During warmer SST episodes in the tropical pacific, referred to as El Nino, Malawi and the most of southern Africa expects below normal annual rainfall whereas Tanzania and the Eastern Africa region receives above average annual rainfall. In contrast, colder SST episodes results in above normal rainfall in Malawi and southern Africa and below normal rainfall in Tanzania and most of the East Africa region.

Historical climatic trends

Assessment studies on historical climate trends in Malawi and Tanzania show a complex pattern.

Tanzania: In Tanzania, analysis of multi-station data from the Tanzania Meteorological Agency (TMA, 2007) showed that both mean annual rainfall and temperature increased during 1950-2006 and 1960-2005 respectively (Fig A1). The rainfall trend was not statistically significant whereas the temperature trend was statistically significant. The TMA (2007) also noted that there was greater rainfall variability in cycles as shown in Fig A1.

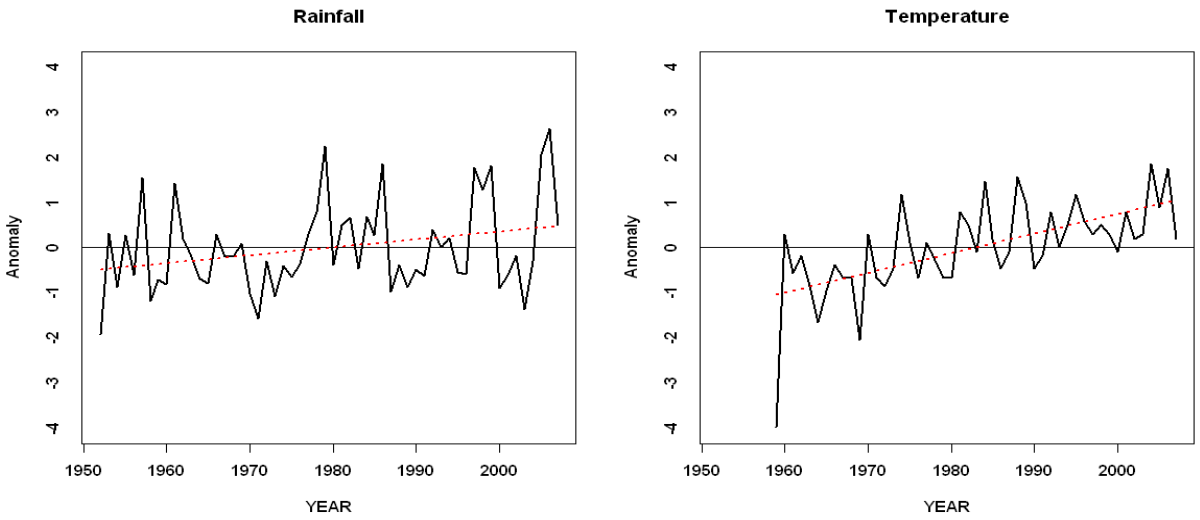

Fig A1. Trends of anomalies of mean annual rainfall and mean annual temperature in Tanzania during 1950-2005 and 1960-2005 from sample stations average. Dashed line depicts the direction of the linear trend.

Climate indices for data collected from weather stations in Central Zone were also analyzed. Daily temperature and rainfall observations from 1960 to 2003 were used. Climate indices were computed based on daily temperature (Tmax & Tmin) and rainfall.

Precipitation indices, 1960 – 2003

When averaged over the whole central zone, precipitation indices (Consecutive dry days(CDD), consecutive wet days (CWD), Annual total precipitation (PRCTOT), Max-1day precipitation amount (RX1day), Max-5day precipitation amount (RX5day, Number of heavy precipitation days (R20), etc) both increasing and decreasing trends are found.

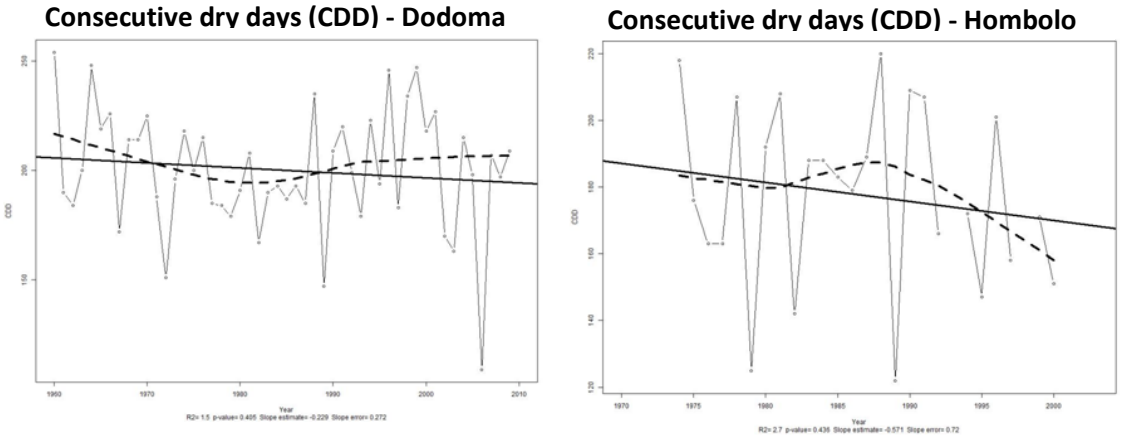

Figure A2. Trends in consecutive dry days for Dodoma and Hombolo stations, Central Zone Tanzania.

A decreasing trend of consecutive dry days can be seen for Dodoma and Hombolo (Fig A2), although these are not statistically significant (p-value of 0.405 and 0.436 respectively). The Dodoma weather station is the closest to the Central Zone project learning sites.

A decreasing trend of consecutive wet days (CWD) was found for Dodoma, but a minor increase in consecutive wet days was found for Hombolo.

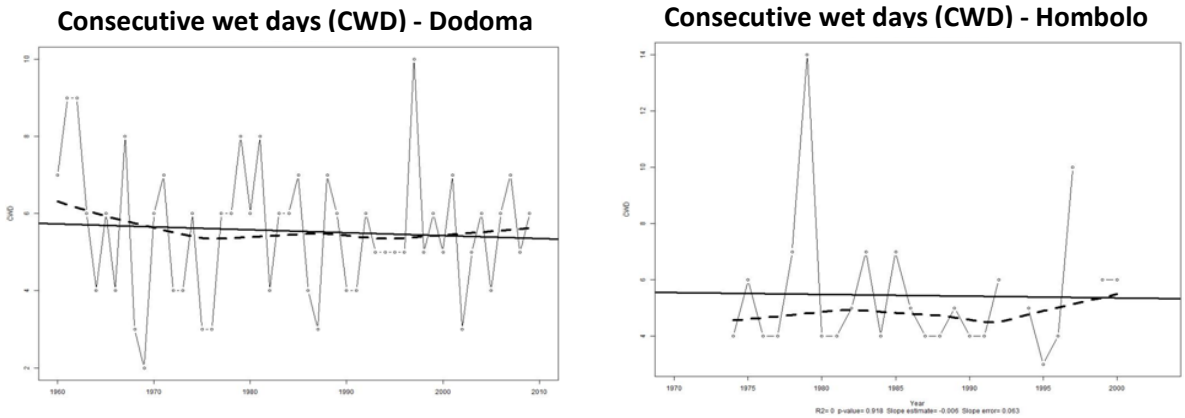

Figure A3. Trends in consecutive wet days for Dodoma and Hombolo stations, Central Zone Tanzania.

Temperature indices, 1960 – 2010.

The temperature indices are percentiles-based indices; these include diurnal temperature range (DTR) (*this is the difference between maximum and minimum temperature*), warm nights (TN90P), cold nights (TN10P), warm days (TX90P) and cold days (TX10P). Only Dodoma weather station has daily maximum and minimum temperature records for this period, and these have been used in calculating these indices.

Decreasing trends were found for Diurnal temperature range (DTR), Cold nights (TN10P) and Cold days (TX10P), while there was an increasing trend of warm nights (TN90P). These results indicate the increasing of temperature in Dodoma area of Central Zone.

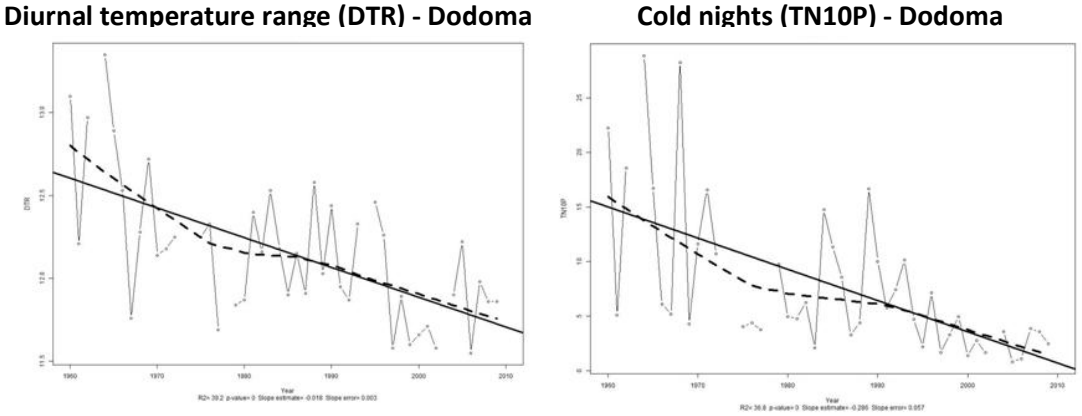

Figure A4a. Diurnal temperature range (DTR), Cold nights (TN10P), Dodoma.

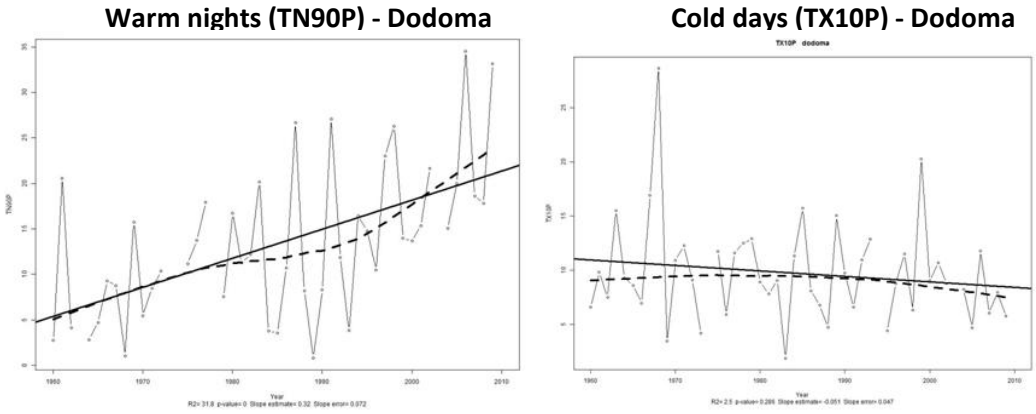

Figure A4b. Warm night (TN90P) and Cold days (TX10P), Dodoma.

Malawi: In Malawi, assessments of key climatic variables showed an overall increase in temperatures and a decrease with decreased rainfall. Figure A5 show trends of anomalies of annual rainfall and mean temperature averaged over Malawi during 1970-2000. Although these trends were not statistically significant, annual rainfall declined with a slope of -3.24mm/year whereas mean temperature increased with a slope estimated at 0.03oC/year.

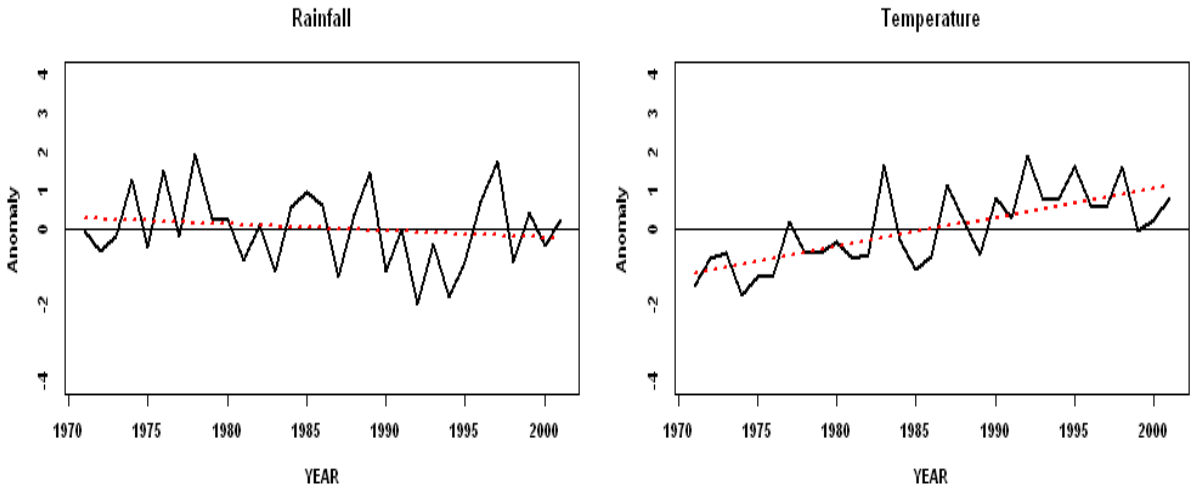

Figure A5. Trends of anomalies of countrywide mean annual rainfall and mean annual temperature in Malawi during 1970-2001. Dashed line depicts the direction of the linear trend.

Similar conclusions of reduced rainfall over Malawi, that were also not statistically significant, were found in a study on temporal rainfall variability over Malawi rainfall by Ngongondo *et al*., (2011) who analyzed a longer time period during 1961-2006. However, the study by Ngongondo et al (2011) established an increase in the inter-annual rainfall variability pattern in Malawi, suggesting that the rainfall pattern in Malawi became more unpredictable. The results of rainfall and temperature anomaly trends from two stations located close to the learning sites at Sitolo Village in Mulanje District (Mimosa Station) and Ntuana Village in Chikhwawa District (Nchalo Station) are presented in Figures A6a & b.

It can be observed that both rainfall and temperature anomalies follow the countrywide trends. Both stations did not show statistically significant trends for the rainfall series, with Mimosa having a negative slope of -1.71 mm/year whereas Nchalo had a slightly positive slope of +0.84 mm/year. Mean annual Temperature showed statistically positive trends with Mimosa having a slope of +0.45 ^{o}C/year while Nchalo had a slope of +0.34 ^{o}C/year.

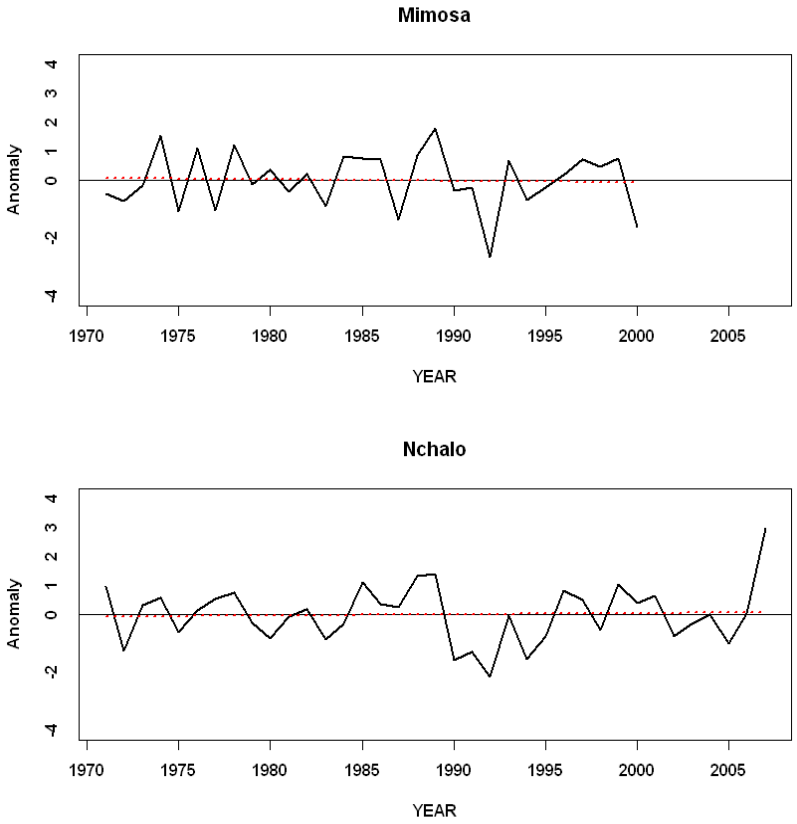

Figure A6a. Trends in annual rainfall anomalies for Mimosa and Nchalo stations in Mulanje and Chikhwawa districts

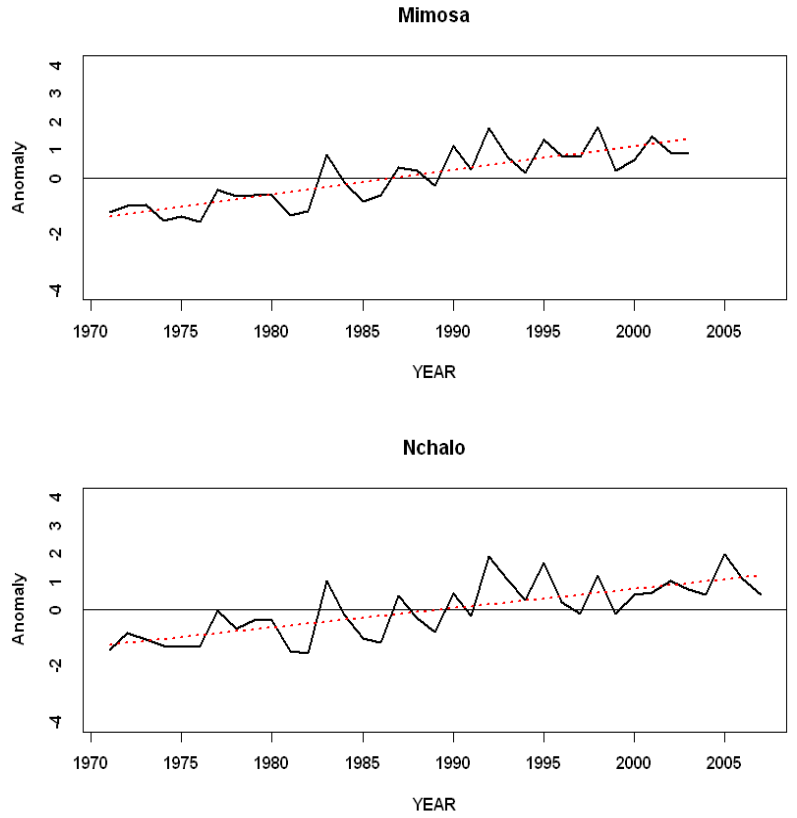

Figure A6b Trends in mean annual temperature for Mimosa and Nchalo stations in Mulanje and Chikhwawa districts

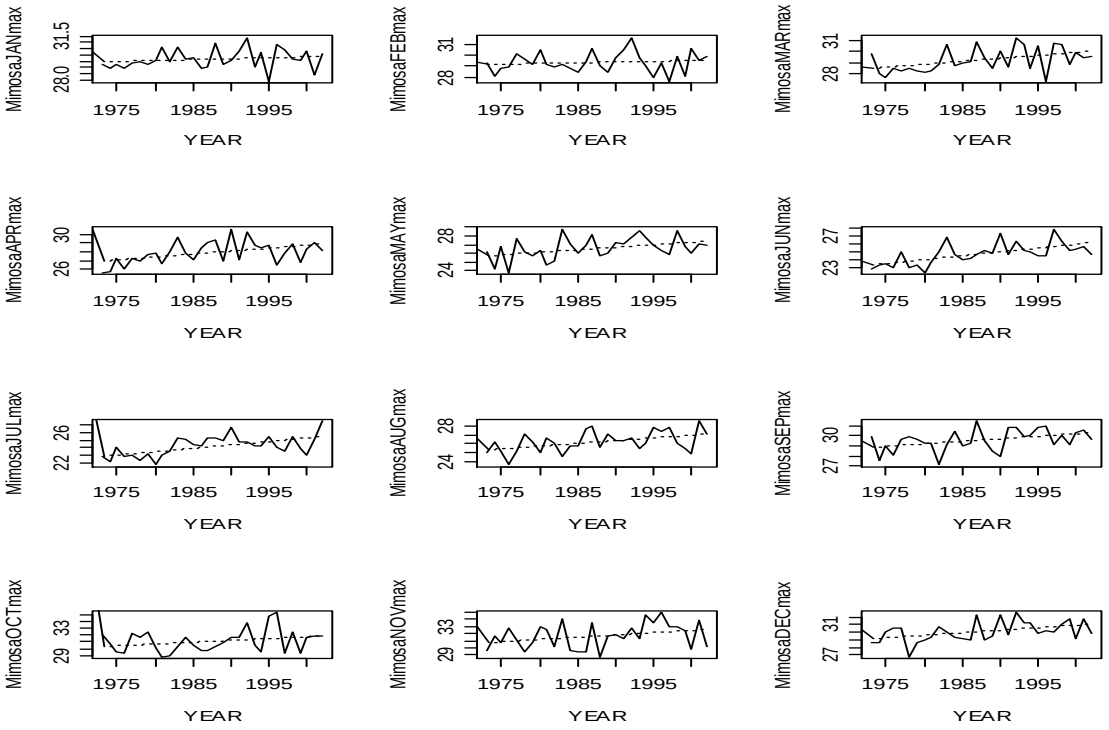

Figure A7a. Monthly maximum linear temperature trends for Mimosa 1972 to 2003

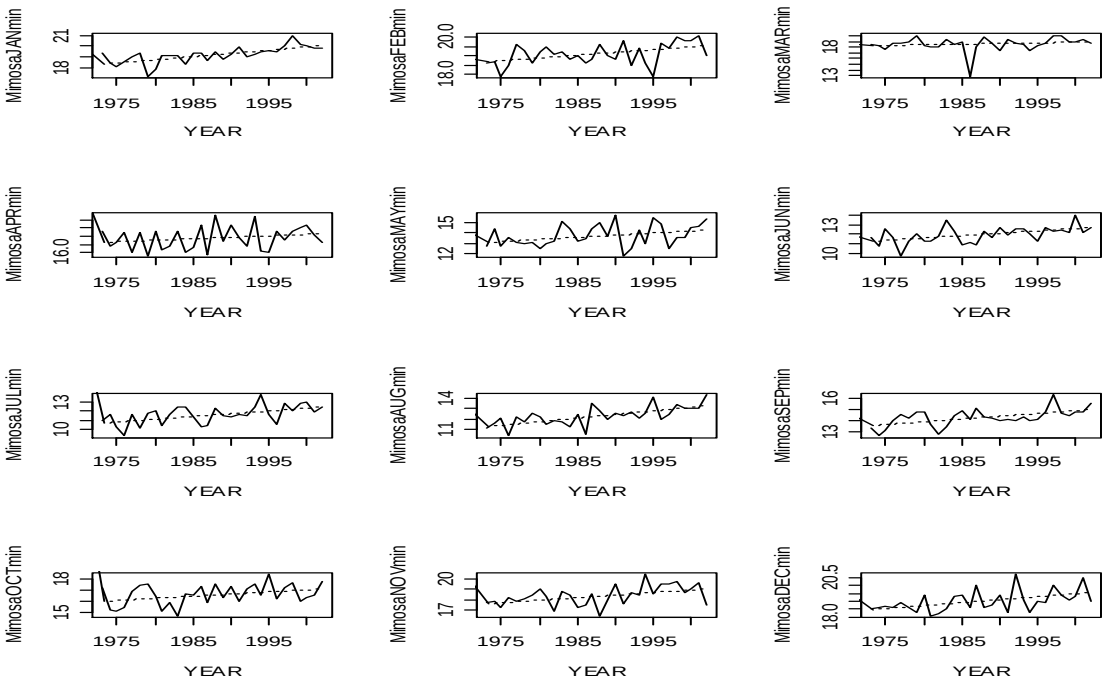

Figure A7b. Monthly minimum linear temperature trends for Mimosa 1972 to 2003

Future climatic projections

Tanzania: Future climate scenarios for Tanzania by McSweeney *et al*., (2008) suggest that the warming trend from the historical series will continue. Mean annual temperature is projected to increase by 1.0 to 2.7°C by the 2060s, and 1.5 to 4.5°C by the 2090s. Figure A8 shows the temperature projections under the A2, A1B and B2 scenarios, with the GCM Ensemble range represented by the upper and lower colour limits.

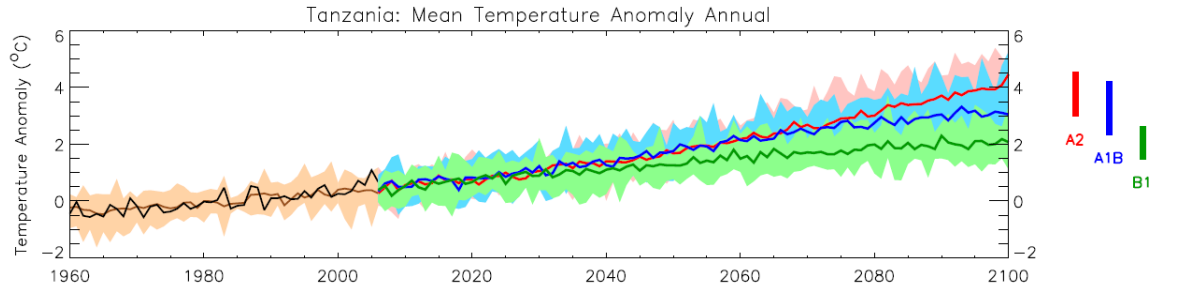

Figure A8. Historical and future projected trends in annual mean temperature over Tanzania relative 1970-1999 mean climate. Observed data from 1960-2006 and 15 model ensemble mean for the scenarios in coloured lines from 2006 onwards (Source: Mc Sweeney *et al*., 2008).

The mean annual rainfall is projected to continue with the increasing trend from the historical series with the GCM ensemble range spanning changes of -4 to +30% by the 2090s, and ensemble median changes of +7 to +14%. Although the annual change patterns are similar, the projection suggest complex the seasonal patterns of change. Figure A9 shows the rainfall projections under the A2, A1B and B2 scenarios, with the GCM Ensemble range represented by the upper and lower colour limits.

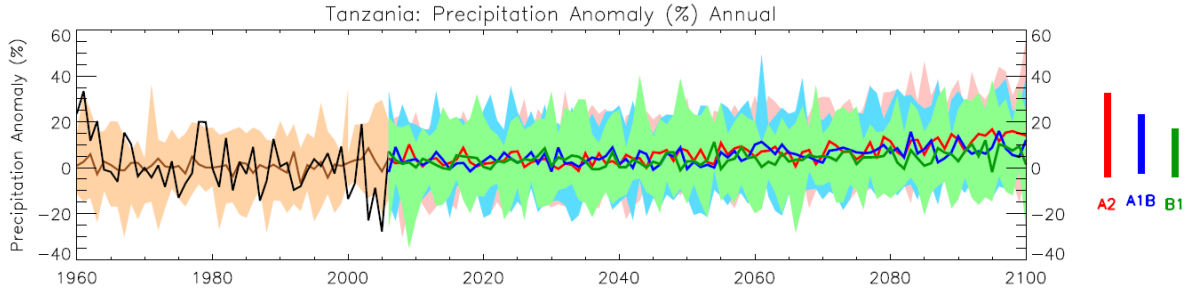

Figure A9. Historical and future projected trends in annual mean rainfall over Tanzania relative 1970-1999 mean climate. Observed data from 1960-2006 and 15 GCM ensemble mean for the scenarios in colored lines from 2006 onwards (Source: Mc Sweeney *et al*., 2008).

Malawi: Projected future temperatures for Malawi under the A2, A1B and B2 scenarios are shown in Figure A10 (Sweeney *et al*., 2008) with the spatial distribution shown in Figure A11. The mean annual temperature is projected to continue with the observed 20th century increasing trend rising by 1.1 to 3.0°C by the 2060s, and by 1.5 to 5.0°C by the 2090s. The range of the different models spans 2.1°C.

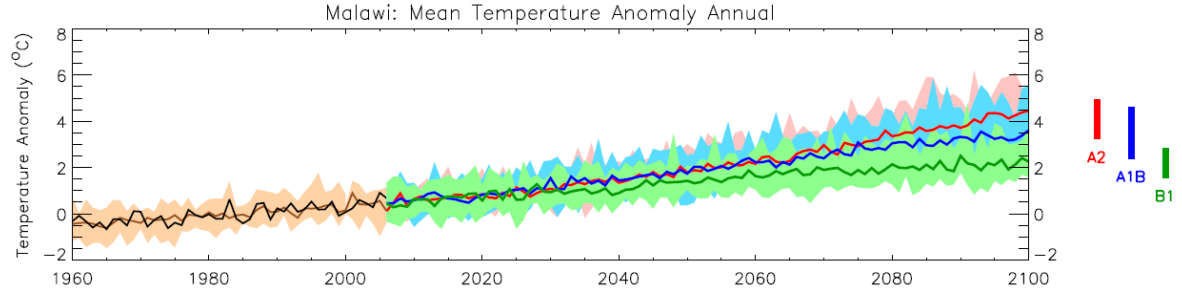

Figure A10. Historical and future projected trends in annual mean temperature over Malawi relative 1970-1999 mean climate. Observed data from 1960-2006 and 15 model ensemble mean for the scenarios in colored lines from 2006 onwards (Source: Mc Sweeney *et al.*, 2008).

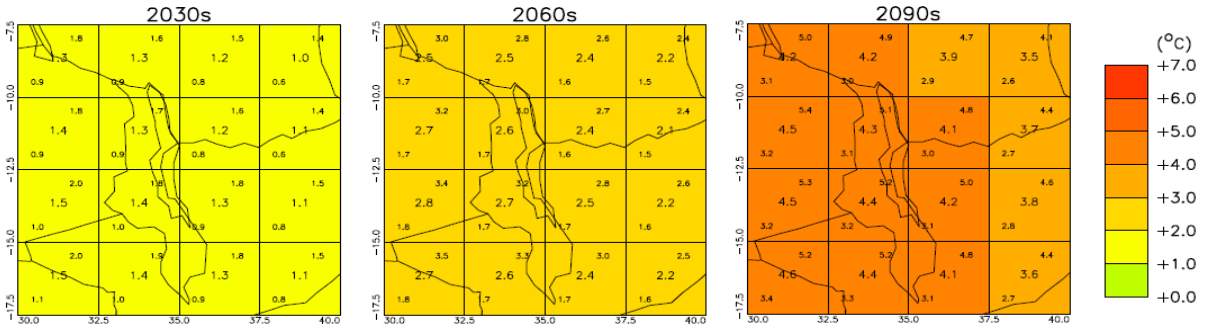

Figure A11: Spatial patterns of projected change in mean annual temperature in Malawi for 10-year periods in the future under the SRES A2 scenario. All values are anomalies relative to the mean climate of 1970-1999 (Source: Mc Sweeney *et al.*, 2008).

As opposed to the increasing rainfall trends in Tanzania, rainfall projections in Malawi do not suggest any substantial changes as compared to the 20th century changes (Figure A12). The GCM ensemble range is large and straddles both negative and positive changes (-13% to +32%). The spatial distribution of the rainfall trends over Malawi is shown in Figure A13.

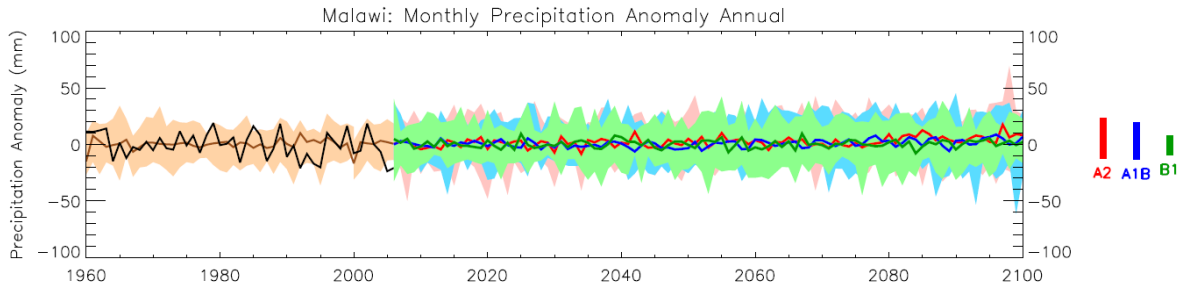

Figure A12. Historical and future projected trends in annual mean rainfall over Malawi relative 1970-1999 mean climate. Observed data from 1960-2006 and 15 GCM ensemble mean for the scenarios in colored lines from 2006 onwards (Source: Mc Sweeney *et al.*, 2008).

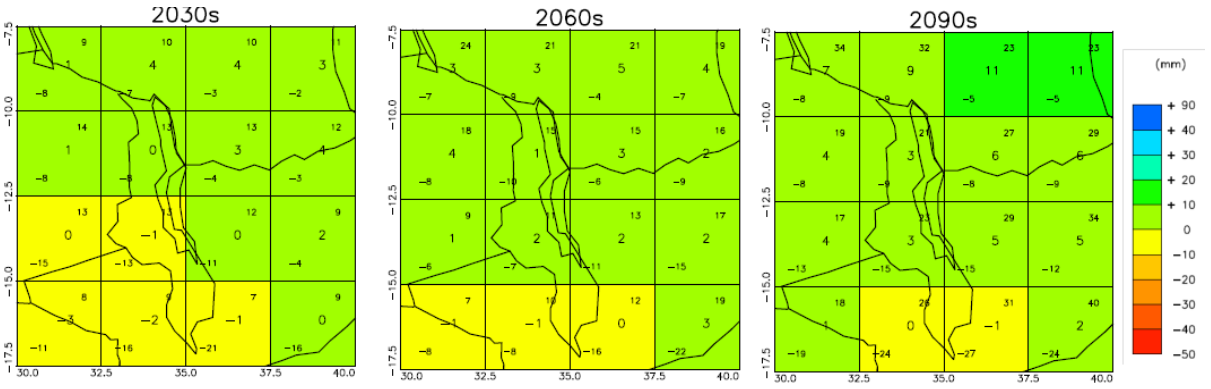

Figure A13: Spatial patterns of projected changes (mm) in mean annual rainfall in Malawi for 10-year periods in the future under the SRES A2 scenario. All values are anomalies relative to the mean climate of 1970-1999 (Source: Mc Sweeney *et al.*, 2008).

Appendix 2. Overview of farmers' observations of their horticultural learning plot outcomes

The experiential learning approach promoted by the project helped peri-urban horticulture farmers together with other stakeholders learn to test different horticultural practices that improved the efficiency of their vegetable production. They now have the skills to continue testing and accessing new knowledge (practices, seeds, market trends etc.) to help them produce vegetables more sustainably for the rapidly growing urban population under current climatic conditions and the increasingly variable climatic conditions projected for the future. Details of some of the practices the learning groups learnt about are described in this Appendix.

CENTRAL ZONE, TANZANIA

Improved Seedbed Practices

The improved seedbeds tested in the learning plots for the various horticultural crops grown in Ihumwa and Mtumba villages were generally characterized by the following features:

- Even distribution of farmyard manure and incorporation of farmyard manure into the soil.
- Use of 1 metre width which allowed easy levelling of plots. This in turn resulted in well levelled plots which ensured uniform watering and infiltration. This width facilitated easy implementation of cultural practices such as thinning, weeding, and harvesting.
- Row planting using a definite spacing as opposed to random broadcasting

NB: The seedbed dimensions introduced were tested on all the horticultural crops growing in the study villages i.e. Ihumwa and Mtumba villages

Traditional Seedbed Practices

In contrast, traditional seedbed plots had an uneven surface level and as a result water tended to concentrate in only a few places, leaving areas of the plot unwatered. In order to implement cultural operations under traditional seedbed practice farmers were obliged to walk through the seedbed which eventually resulted in soil compaction. Under traditional seedbed practice there is no incorporation of farmyard manure into the soil. Furthermore, traditional seedbed practice involved broadcasting of seeds which result in very uneven plant density.

The following paragraphs describe the yield assessment and harvest data obtained when farmers compared the use of improved seed beds with their traditional seedbeds for a number of horticultural crops.

Leafy vegetables:

Across locations (Ihumwa and Mtumba villages) it was observed that farmers were not harvesting the leafy vegetables (Chinese, Amaranthus and onions) themselves, instead buyers/traders negotiate on the price while the crop is still in the field and the bargaining largely depends on the visual quality of the crop and not the weight/amount of produce as applies in other places. Thereafter, harvesting and transportation of harvested produce is decided on and implemented by the buyers/traders. For the learning plot trials, data was collected to capture the comparative income earned from the improved and traditional seedbeds.

Chinese cabbage:

This study involved the use of a Mother plot acquired from Betty Ng'hambi. This consisted of four plots, each 5 m long and 1 m wide for improved seedbed practice. In contrast, traditional practices consisted of two plots, each with 5 m long and 2m wide. Improved and local practice seed beds each covered a total area 20 m^2.

Harvesting of the improved and traditional plots differed. Interestingly, the plants in the improved seedbed had quicker growth rate which resulted in earlier plucking than in the traditional plots (Table A2.1). The second plucking of improved seedbed coincided with first plucking of the traditional seedbed. The leaf quality in the improved seedbeds attracted customers/buyers. The preference for the improved seedbed produce was mainly attributed to the broad and deep green leaves which formed as opposed to the poorer and narrow leaves produced under traditional seedbed practice. The improved seedbed gave an average of eight (8) plucking compared to only four (4) plucking for traditional seedbed. Total earnings from the improved seedbeds area was 294,000 TZS in contrast with 83,000 TZS from the traditional seedbed area.

Findings revealed that the use of well levelled plots increased water use efficiency. Watering was done every three days after crop establishment in the improved seedbed plots. Whereas, the traditional seedbed plots required watering either every day or every two days. The study also noted that row planting facilitated light tilling which enhanced uniform soil water percolation/infiltration and hence better crop performance in comparison to the broadcasting planting method of the traditional seedbed plots. Given the projected climate trends of increasing temperature in this area, agricultural practices which increase soil water conservation are crucial in helping farmers adapt their agricultural livelihoods to the impacts of the projected climatic changes.

Table A2.1: Sales of Chinese cabbage

Plucking dates	Income (TZS) obtained per Seedbed Type	
	Improved seedbed (20 m^2)	Traditional seedbed (20 m^2)
09 May 2011	40,000	-
16 May 2011	60,000	25,000
23 May 2011	55,000	36,000
01 June 2011	50,000	20,000
08 June 2011	45,000	2,000
17 June 2011	30,000	-
27 June 2011	10,000	-
09 July 2011	4,000	-
Total	**294,000**	**83,000**

Onion leafy (spring onion)

It has been noted that across study sites in Central zone, onions are mainly grown for leaf production as opposed to their bulbs and they are normally harvested at two months after transplanting. Findings revealed that spring onions (planted 20/3/2011, transplanted 18/4/2011, harvested 18/6/2011) established under improved seedbeds which involved the incorporation of farmyard manure and planting at spacing of 15 cm by 15 cm resulted in better crop performance as judged by the thicker growing points, deeper green and quicker maturity of the plants. In contrast, the traditional seedbed resulted in delayed maturity and yellowing of leaves of the plants.

The mother plot had 5 plots, each 10 m long and 1 m wide thus giving a total of 50 $m^{2.}$ Conversely, the traditional practice consists of 10 m long and 2 m wide. Spring onions established on the improved seedbeds attracted many customers/buyers and produce was sold at TZS 120,000/= compared to only TZS 40,000/= from the same area of traditional seedbed.

Amaranthus

Similarly, Amaranths established using the improved seedbed fetched a better price than the Amaranthus grown on the traditional seedbed. As described above, the incorporation of FYM and the use of a 1 metre width resulted in better crop performance. Price negotiations were agreed at 30,000 TZS/plot under improved seedbed and 15,000 TZS/plot under traditional seedbed. The latter had yellowing leaves and stunted plant growth was evident. Mother plots consisted of 8 plots each 8 m long and 1 m wide for improved seedbed. The traditional seedbed consisted of 4 plots each 8 m long and 2 m wide. Management of this plant has always been difficult under traditional seedbed.

Total amount of money earned from sales of Amaranthus was 240,000 TZS under improved seedbed and 60,000 TZS under traditional seedbed. The plots were harvested on 14 April 2011.

Tomato

The improved seedbed trial consisted of 5 plots, each 9 m long and 1 m wide. The farmyard manure was applied uniformly across the plot before ploughing and thereafter followed by incorporation of FYM during ploughing and levelling. The traditional seedbed area was comprised of two plots, each 9 m long and 2.5 m wide. The traditional seedbed involved ploughing of land and planting of seedlings. Later farmyard manure was spread on top of the traditional seedbed without incorporation (this is farmer's normal practice). Regardless of the seedbed type used, the same frequency of harvesting resulted. The only difference was in the number of buckets of tomatoes harvested (Table A2.2).

Table A2.2: Tomato yield (kg) as affected by farmyard manure incorporation and spacing

Harvest dates	Number of buckets of tomatoes harvested	
	Improved seedbed ($45m^2$)	**Traditional seedbed** ($45m^2$)
31 May 2011	6	3
04 June 2011	10	6
11 June 2011	15	8
17 June 2011	16	8
26 June 2011	18	7
30 June 2011	10	3
09 July 2011	5	2
Total	**80**	**37**

MALAWI

Climate change and impacts on rural urban linkages

During the project baseline studies, it was learnt that there was clear evidence of climate change and variability, starting as far back as 1949. Rainfall and temperature were the most frequently used indicators for change. Farmers reported generally declining rainfall trends over the years, a shortened rainfall season, delayed, unpredictable onset and early cessation of rains in addition to prolonged and frequent episodes of dry spells. Further, the temperatures trends suggest more warming and winds had become stronger. There was a general consensus among the farmers perceived that the higher temperatures being experienced were associated with the reduced rains. In addition, farmers in Mulanje and Blantyre reported that the cold season (May-July) had become colder, while in Chikhwawa it had become warmer. Their perceptions regarding climate change and its impacts were in general agreement with scientific evidence.

Peri urban areas are important sources of vegetables consumed in urban areas. Vegetables are also an important part of poor urban household diets. Low yields of vegetables from producing sites

therefore translate into low supplies in urban markets and higher costs for poor urban households. Vegetable production is an important livelihood activity in peri urban areas. For example, in Ntwana village about 70% of household income is derived from vegetable production, while rainfed cereal production is now almost impossible due climate change effects. However, vegetable production is seasonal, and managed largely through dry season irrigation and is therefore very prone to climate change effects affecting irrigation water availability.

Seasonality of horticultural crops

Production of vegetables at both study sites is mainly done in the cold dry season (from March/April to September/October) as the rainfall pattern in the main rainy season negatively affects leafy vegetable production. High rainfall results in the vegetables rotting and failing to meet market quality standards. In good rainfall seasons (hot and wet), insects population also increase and these can destroy vegetable leaves. While inadequate rains results in the drying of vegetables as there is no back up for irrigation. In general, the farmers do not risk indulging in rain-fed leafy vegetable production. Tomatoes, egg plants and podding vegetables including fresh beans and cowpeas also do not produce good quality fruits/pods during the summer/rainy season. Farmers reported that the plants flourish vegetatively and flower very well but abortion prevails. This has scientific backing as this environment is not conducive for flower retention of such crops.

In addition to declining soil fertility, increased prevalence of pests and diseases, low profits, a shortened rain season reduces the water recharge hence affecting water available for irrigation as rivers dry faster and the water table is lowered. Furthermore, the shorter cold season suggests a shorter vegetable growing season. This translates into high market food prices for many months thereby affecting the disposable income available for food items in poor urban households. Urban poor households in such situations are therefore more vulnerable to food insecurity and climate change.

Volumes of horticulture production

Vegetable production in Ntwana, Chikhwawa district was characterised by low realization prior to this project's attention. On average, prior to the project a farmer would expect to harvest 2 to 3 baskets for 4 to 6 weeks from a quarter or half an acre depending on the stage of growth, crop type and management practices and water availability. In a good year farmers could grow 2 to 3 crop cycles and thus realise more income. A single cycle could earn them between MK5,000 to MK10,000 per acre. Before the project a few households were earning up to MK30,000 annually from vegetable production. This is twice the amount realised from fresh maize sales from a similar land holding size.

State of technical extension services, inputs sources and markets

Farmers reported that in general, there is very limited horticultural technical extension service provision in the area. The farmers therefore mostly learn from each other. The farmers generally considered current technical extension services on soil fertility management, especially on manure preparation and application, adequate. However, not all farmers were using manure in their gardens due labour demands. Where affordable, inorganic fertilizers were used on some vegetable species such as tomato, mustard, rape, cabbage, onions, spinach etc. Farmers indicated that they had little knowledge on recommended practices such as the right crop varieties and types and quantities and when to apply the manure. Their traditional practices do not include any regular plant spacing, or soil fertility regimes. Although some farmers reported knowing how to apply chemicals to prevent plant diseases. In the Chikhwawa district sites, most farmers obtain agricultural inputs from agro-dealers at the nearby Dyeratu Market Centre. However, the suppliers do not always stock all the required inputs including chemicals. Farmers desired changes included: improvement in horticultural production through quality and varieties; market availability and reliability; improved technical

expertise on horticulture production such as management of crops, pests and diseases; enhanced extension services and improved irrigation techniques.

Project intervention approach

The project adopted a Participatory Action Research (PAR) approach to enhance participation, understanding and adoption of suitable horticulture production practices in the focal villages, Ntwana in Chikhwawa and Sitolo in Mulanje. In addition, the farmers then underwent village based training workshops on climate change and effects on horticultural production, entrepreneurship skills and field based recommended horticultural practices. This mainly involved learning by doing practical activities. A farmers' learning visit to Zakudimba Farmers Cooperative in Bvumbwe, Thyolo District was organised for 53 farmers from each of the villages. Zakudimba Cooperative is typical a model of successful farmers entrepreneurship cooperative where they are processing vegetables. It inspired the newly formed learning groups.

In the first year (2010/11), learning sites were set up to compare traditional and recommended practices so that farmers could use their own experiences to decide on which practices resulted in increased production. The traditional practices and sites with no crop mulching and no manure application acted as control plots.

In the second year (2011/2012), farmers in Ntwana village focussed on successful selected technologies and crops only. It should be noted that the area under vegetable production as well as yields and sales for both experimental and adopters plots increased in the 2011/12 season.

In 2011, experimental plots in Sitolo Village were laid out for each crop and each of two farmers clubs was responsible for management of the experiments. Seeds for tomato, mustard, rape, Chinese cabbage and eggplants were raised on nursery beds 2 m X 1.2 m per crop variety. These were later transplanted to 1.2 m wide and 3 m long production beds. Table A2.3 shows the 8 treatments used for each crop in Sitolo village. The compost and animal manure treatments were incorporated into the soil to enhance water holding capacity.

Table A2.3. Crop treatment plots in Sitolo Village

Mulching with grass + Compost manure	Compost manure
Mulching with grass + Animal manure	Animal manure
Mulching with grass + Fertilizer (23:21:0+4S) applied at planting	Fertilizer (23:21:0+4S) applied at planting
Mulching with grass + No fertilizer	No fertilizer

In mid December 2011, very high temperatures were experienced which led to the drying of most sources of irrigation water. As a result, most of the crops in all plots dried before maturity. Although crops which were mulched with grass were healthier than those without. Farmers noted that mulching reduced evaporation and the number of times irrigation was required. In addition, plots where manure was applied had better crop performance than those where only fertilizer was applied. Most seedlings sown together with fertilizer registered poor performance and others did not germinate. Hence manure application combined with mulching was selected as the best practice under high temperatures and low water supply. While some farmers preferred the mulching with grass plus incorporated animal manure, others preferred the mulching plus compost manure. Livestock per capita ownership is low making animal manure more expensive than compost manure.

Similarly, analysis of the results in Ntwana learning plots (2010/2011) shows that farmers mostly registered high yields where compost manure or mulching were applied as treatments as shown in Tables A2.4 - A2.10. The farmers therefore chose a combination of compost or livestock manure and mulching as best practices as this clearly demonstrated increased productivity.

Table A2.4: Yields of Rape for Tigwirizane and Chiyanjano Groups, Ntwana Village (2010/2011)

Treatment	Tigwirizane group[6]		Chiyanjano group	
	Number of leaves	Weight of leaves (kg)	Number of leaves	Weight of leaves (kg)
Mulching	96	6.5	655	36.5
Compost manure	103	4.0	1418	49.5
Cattle manure	97	6.0	1090	30.5
Cattle manure + Mulching	58	3.25	1270	44.5
No mulching	103	4.5	405	21.0
No manure	83	4.5	362	8.5
Compost manure + Mulching	93	5.5	2255	65.5

Table A2.5: Yield of Onions for Tigwirizane and Chiyanjano Groups, Ntwana Village (2010/11)

Treatments	Tigwirizane Group		Chiyanjano Group	
	Number of bulbs	Weight (Kg)	Number of bulbs	Weight (kg)
Mulching	306		325	15.5
Compost manure	304		316	27.5
Cattle manure	290		272	19.0
Cattle manure + Mulching	292		303	24.0
No mulching	305		197	9.5
No manure	300		270	9.0
Compost manure + Mulching	303		330	38.0

Table A2.6: Yield of Cabbage for learning groups in Ntwana Village (2010/11)

Treatment	Tigwirizane Group		Chiyanjano Group	
	Number of heads	Weight of heads (kg)	Number of heads (kgs)	Weight of heads (kg)
Copenhagen + Compost manure	24	73	60	58.0
Copenhagen with no manure	23	69	57	27.5
Copenhagen + Cattle manure	11	33	57	46.0
Marcanta + Compost manure	21	70.5	69	74.0
Marcanta with no manure	16	67	53	23.5
Marcanta + Cattle manure	16	66	58	52.0

Table A2.7: Yield of maize for Tigwirizane Group, Ntwana Village (2010/2011)

Treatments	Number of Cobs	Weight of cobs (kg)
PAN 67 + Compost manure	149	82.0
PAN 67 with no manure	81	40.0
PAN 67 + Cattle manure	99	44.5
SC 403 + Compost manure	124	78.0
SC 403 with no manure	94	55.0
SC 403 + Cattle manure	114	61.0

[6] Unfortunately just as Tigwirizane group had started harvesting their crop, they were chased from their learning plot by the envious owner. Hence the results shown are from one harvest only, while those in Chiyanjano are for several harvests. The crop stand in Tigwirizane learning plot was very impressive compared to Chiyanjano, suggesting that if they had the opportunity to harvest throughout the whole season, their yield data would have been higher than Chiyanjanos.

Table A2.8: Yield of Tomato for Chiyanjano Club, Ntwana Village (2010/2011)

Treatments	Number of fruits	Weight of fruits (kg)
Mulching	178	12.0
Compost manure	509	26.5
Cattle manure	324	15.5
Cattle manure + Mulching	590	22.5
No mulching	169	8.5
No manure	107	6.0
Compost manure + Mulching	741	41.5

Table A2.9: Yield of Mustard for Chiyanjano club, Ntwana Village (2010/2011)

Treatments	Number of leaves	Weight of leaves (kg)
Mulching	500	19.00
Compost manure	626	34.50
Cattle manure	567	24.50
Cattle manure + Mulching	644	33.25
No mulching	218	12.25
No manure	170	6.75
Compost manure + Mulching	841	42.25

Table A2.10: Yield of Okra for Chiyanjano Club, Ntwana Village (2010/2011)

Treatment	Number of fruits	Weight of fruits (kg)
Local variety + Compost manure	500	29.5
Local variety with no manure	199	11.5
Local variety + cattle manure	329	20.5
Clemson spineless + compost	651	36.5
Clemson spineless with no manure	221	15.0
Clemson spineless + cattle manure	438	24.0

Farmers in both villages indicated that through the implementation of learning plots, they have learnt how to achieve higher yields and quality produce than before while using less land and water, aspects important in mitigating, coping with and adapting to climate change.

Effects of mulching in Ntwana where high temperatures and strong sun are experienced all year round revealed reduced irrigation times due to considerable improvement in water retention. This in turn resulted in increased productivity in addition to labour savings in the 2010/2011 plots. The practice was observed to be one of the best practices and was therefore implemented in the 2012 learning plots, and was also widely adopted in individual fields.

Use of compost and animal manure was also adopted for increased water retention and soil nutrition in all group and individual plots. In Ntwana, farmers also planted short season crops such as rape and mustard in smaller plots but in a staggered manner to maximise yields and profits over longer periods. However, longer season crops such as green maize, onion and cabbage were planted on bigger plots with less staggering. In Sitolo Village, farmers concentrated on staggering of short seasoned crops as Chinese cabbage, mustard, rape and snap beans as important business crops. Some individual farmers in Sitolo also deepened their wells to reserve water for longer term usage.

Vertical tower garden technology was introduced as an adaptation measure. The technology was introduced in Sitolo Village and was widely adopted to facilitate vegetable production at individual homesteads. The advantages of the technology include less water and land usage and the farmers observed fewer occurrences of pests and diseases. Furthermore, the farmers reported that it is an ideal technology for the sick, aged and children since they may practice it at their homestead instead of walking long distances. This technology is also ideal for areas experiencing land pressure.

Proceeds obtained from initial sales in Ntwana showed income had increased >20 times compared to that earned using traditional practices on similar sized pieces of land. The total sales were beyond the annual amounts which could be obtained before the project began working with the groups. For example, prior to the project a farmer might obtain MK10, 000 (or at a maximum MK30,000) per year from the same sized piece of land. After the projects actions, three farmers interviewed in each group had obtained about MK200,000 each in the 2012 irrigation season. Figures A2.1 to A2.10 shows the crop yields, income and total area used in crop production for the two learning groups in Ntwana Village.

The crop sales rankings showed that rape ranked first followed by tomato, onion, maize, mustard and then cabbage for Chiyanjano Club. Thus the best selected crops include rape, tomato, onions mustard maize and cabbage. It should however be noted that smallholder growers own small landholdings of less than a hectare but collectively produce large quantities of vegetables.

Figure A2.1. Yield from individual farmers from Ntwana groups

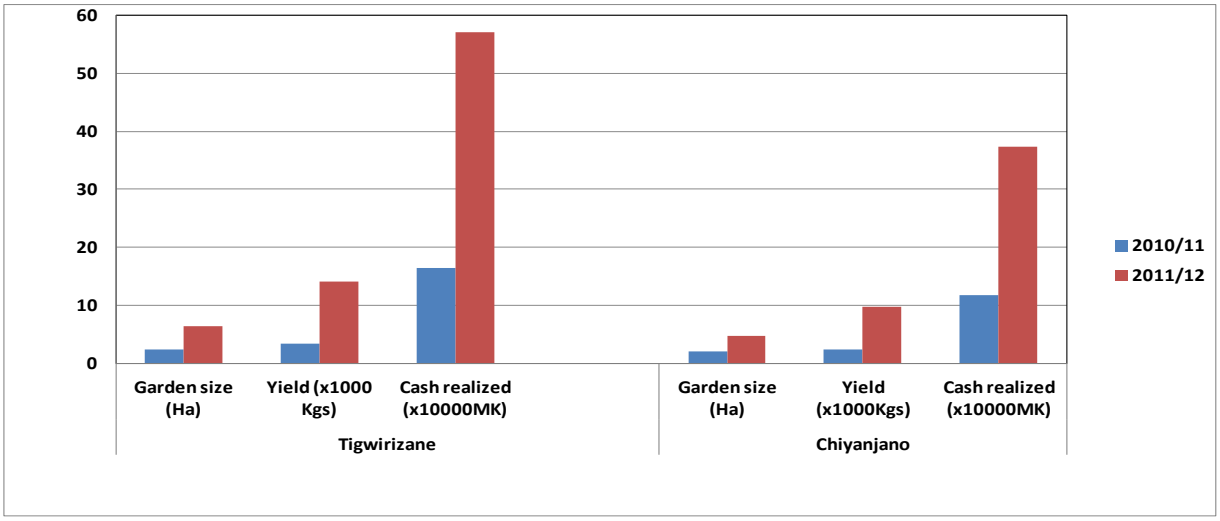

Figure A2.2. Yield from learning plots in Ntwana village for two growing seasons

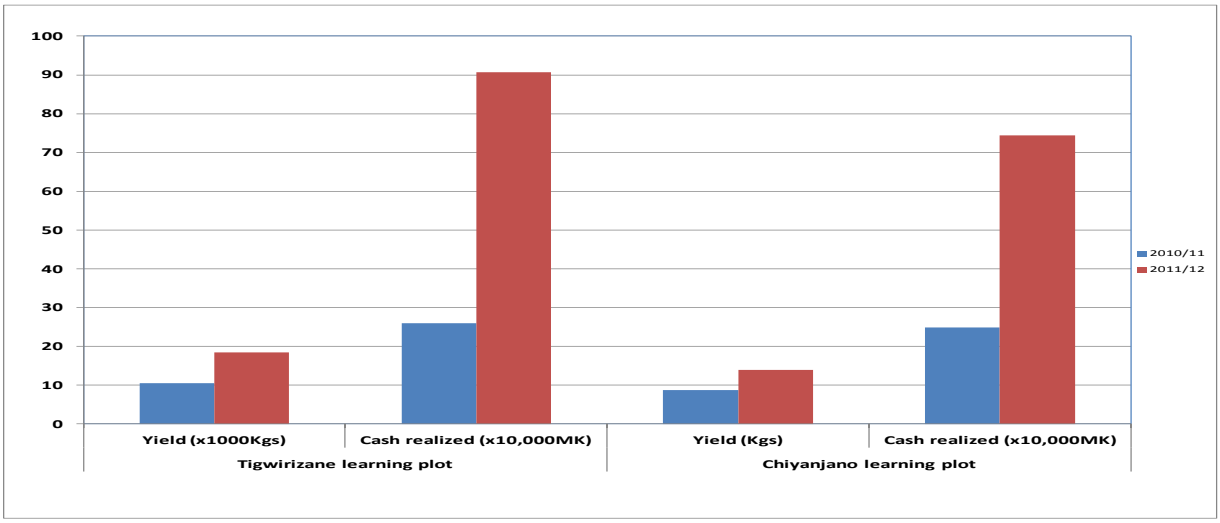

Figure A2.3. Types of vegetables grown on learning plots in 2010/11 and 2011/12 season – Tigwirizane Club

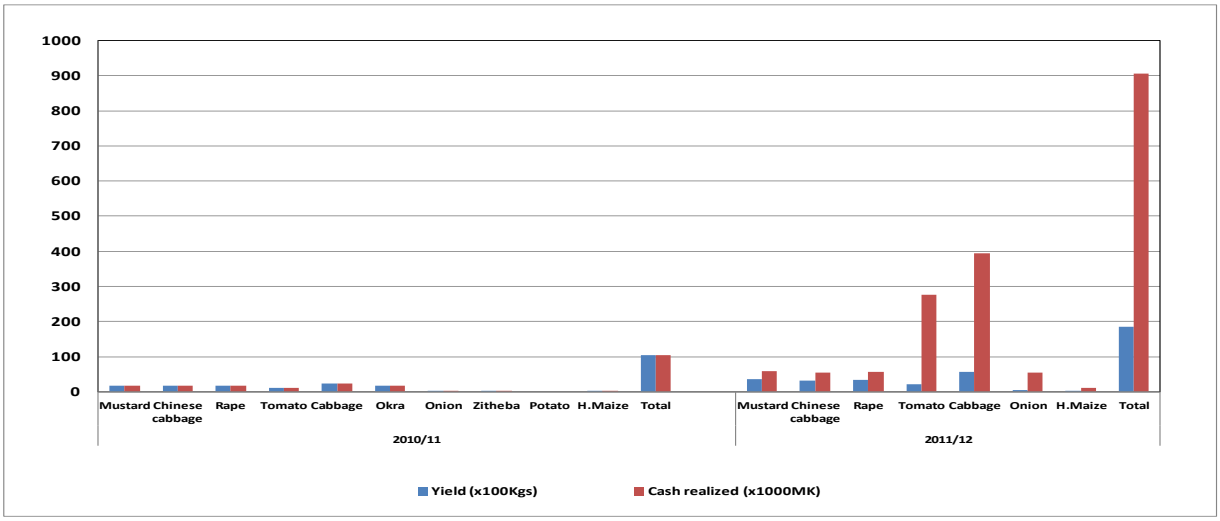

Figure A2.4. Types of vegetables grown by individual members in 2010/2011 and 2011/2012 season – Tigwirizane Club

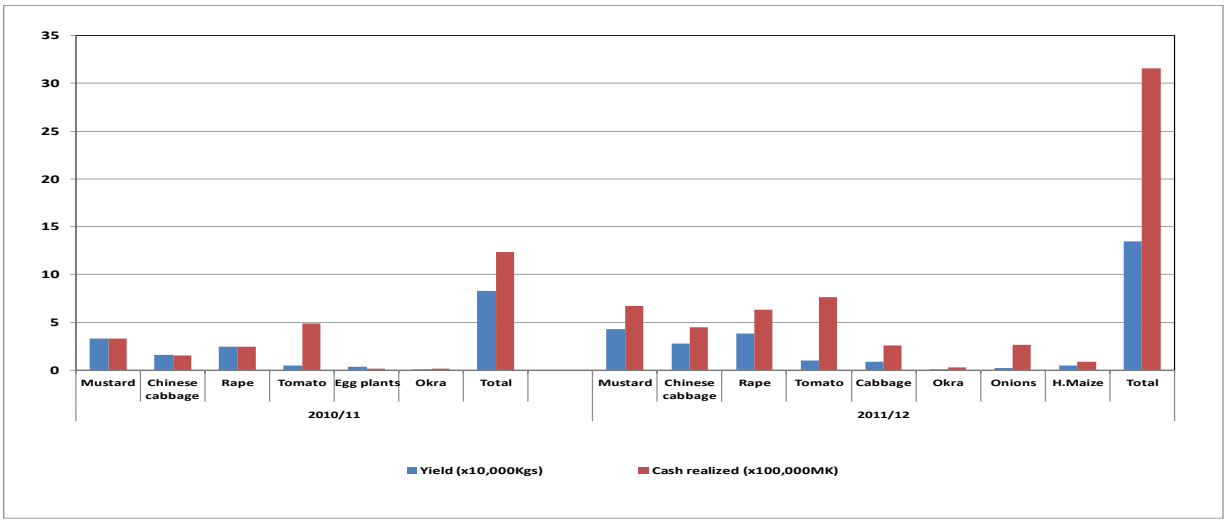

Figure A2.5. Types of vegetables grown on learning plot in 2010/11 season – Chiyanjano Club

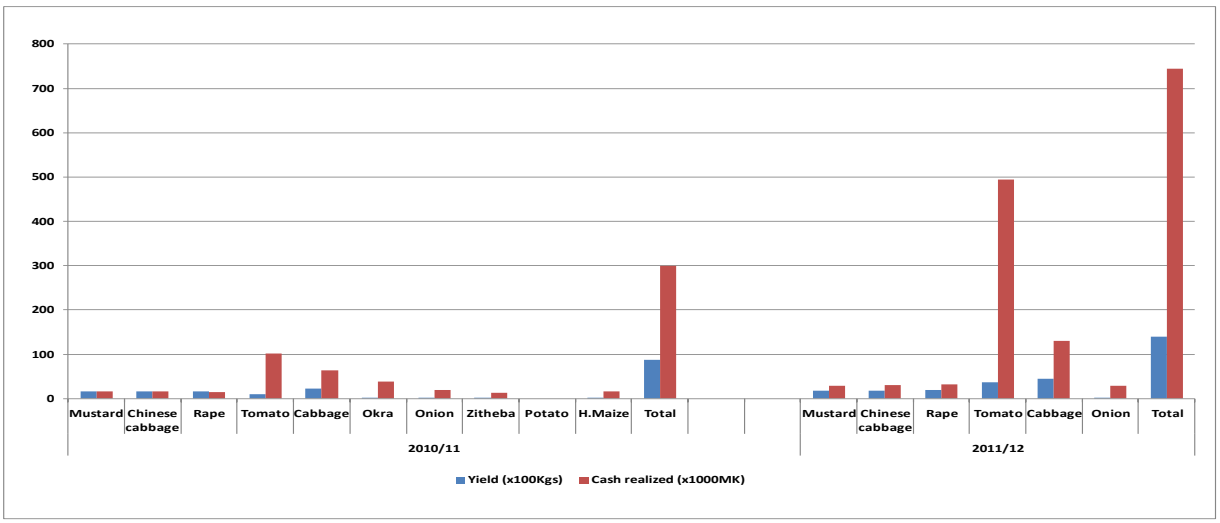

Figure A2.6. Types of vegetables grown on individual plots in 2010/11 and 2011/12 season – Chiyanjano Club

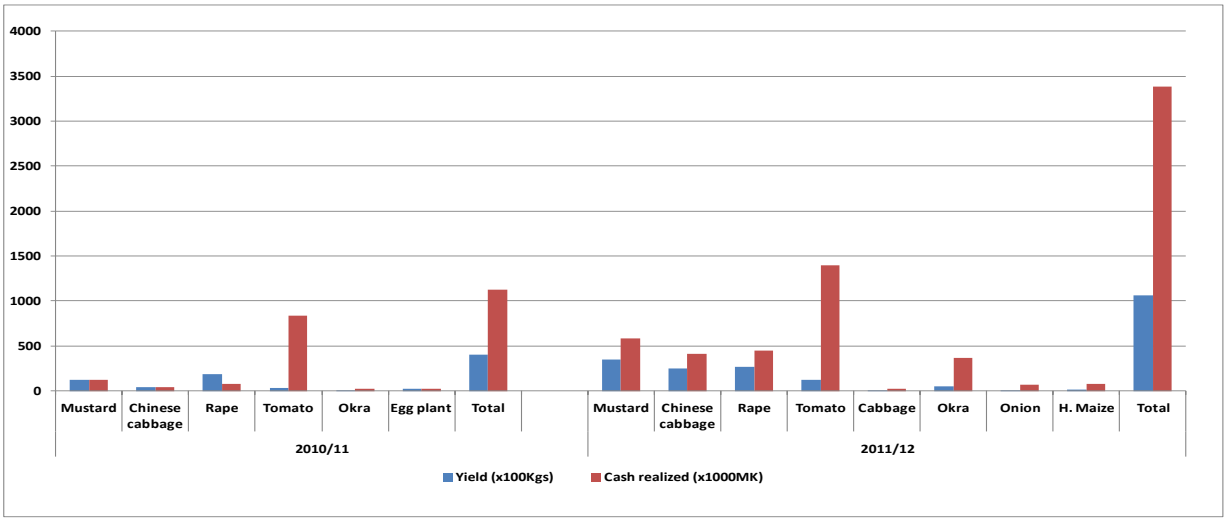

Figure A2.7. Change in acreage by individual members in 2010/11 and 2011/12 seasons – Tigwirizane Club

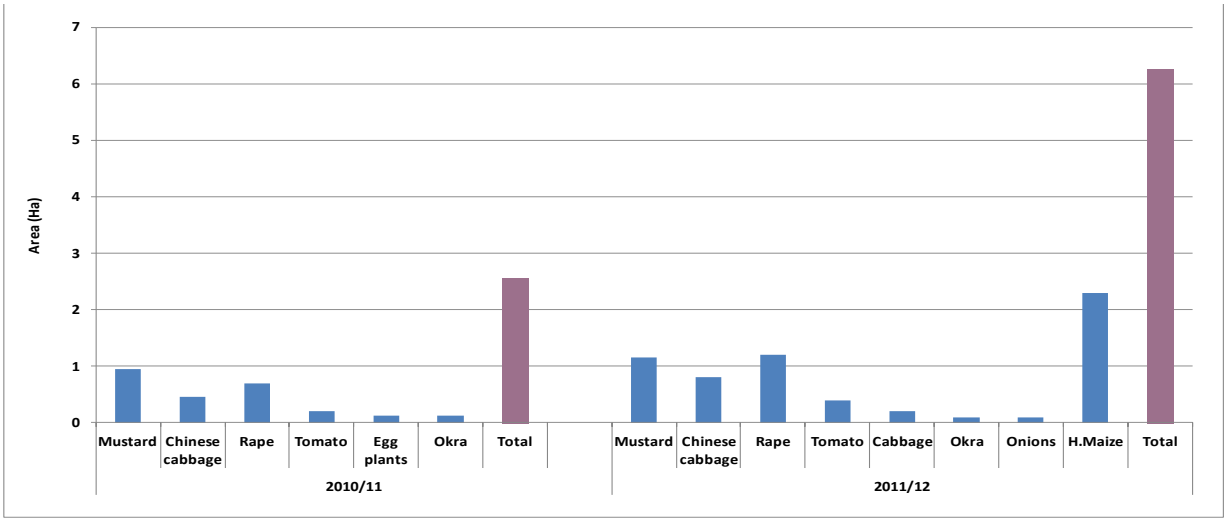

Figure A2.8. Change in acreage on learning plots in 2010/11 and 2011/12 seasons – Tigwirizane Club

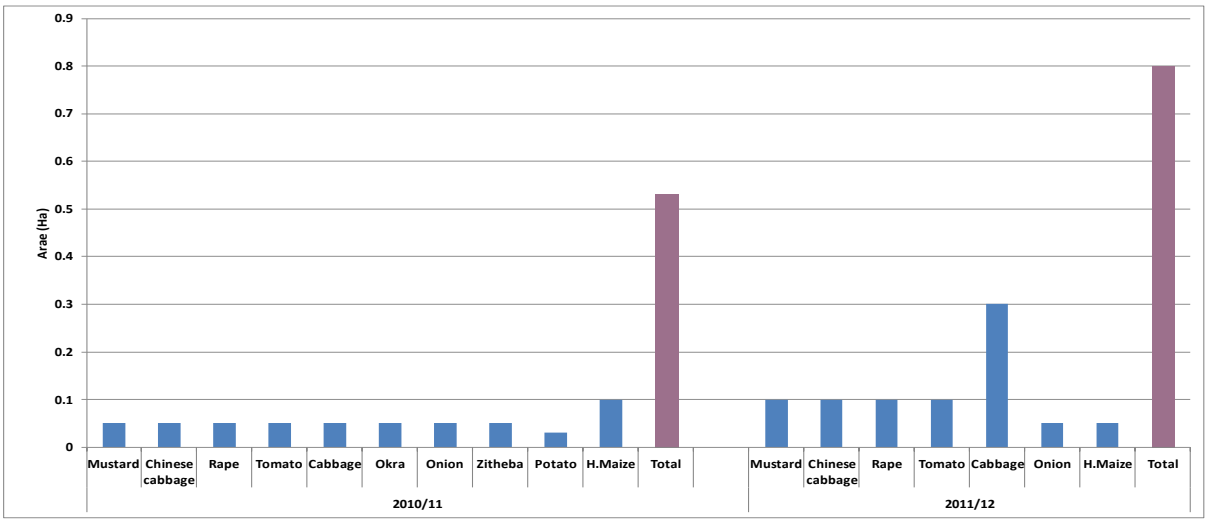

Figure A2.9. Change in acreage by individual members in 2010/11 and 2011/12 seasons – Chiyanjano Club

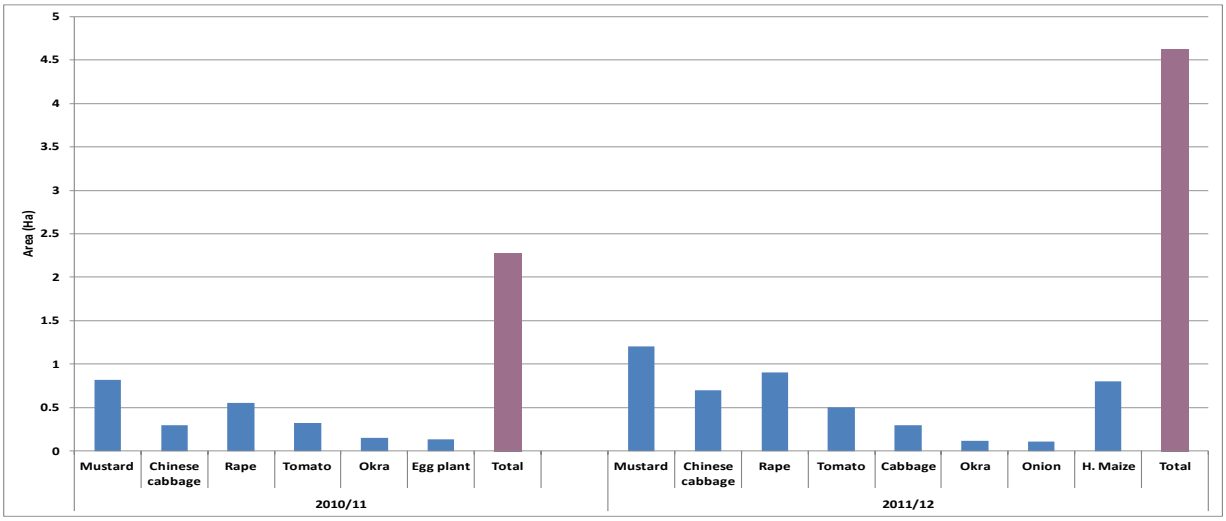

Figure A2.10. Change in acreage on learning plots in 2010/11 and 2011/12 seasons – Chiyanjano Club